NEW ANGLES TO THE STARTER-MAKER'S PROBLEM

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INTRODUCTION

Since the introduction of starters in 1890 their use has gradually increased until at the present time they are employed in all the important dairy countries of the world in the manufacture of such products as butter, cheese, and fermented milk drinks.

There has been some opposition in the United States during the last few years to the use of starters in the manufacture of butter, due presumably to the exceptional keeping quality of some of the butter made from sweet cream without added starter. In the making of butter of a good and uniform quality with a high aroma and flavor, however, starters have an important place and they seem to be particularly beneficial when the quality of the raw material supplied to the butter-maker is not of a high grade so that the development of a pleasing aroma and flavor becomes very essential. Any disadvantages that starters may have, such as causing a rapid deterioration in butter, seem to be due to high ripening and accordingly can be quite readily overcome. In sections of the country in which the use of starters had become rather uncommon they are again being employed as a means of improving the quality and uniformity of the butter manufactured from gathered cream. It is probable that in spite of the opposition to them on the part of certain individuals starters are more firmly established in the American butter industry than ever before.

THE ACID DEVELOPED IN STARTER

When milk or cream is inoculated with a starter the most significant change that occurs is the development of acid. The acids present in fermented milk or cream can conveniently be divided into two classes as follows: (1) non-volatile, the most

important one being lactic, (2) volatile, acetic acid probably being of the most importance.

Lactic acid has a definite sour taste but is odorless so while it influences the taste of fermented milk or cream it cannot directly be of importance from the standpoint of odor. The volatile acids have a significant influence on the aroma and flavor of fermented milk or cream but they are of little importance alone because the milk constituents have the ability to combine with acids; when however lactic acid is present, the volatile acids are, in part at least, set free and they can then become of direct importance in the aroma and flavor development.

The acids present in cream in addition to influencing the aroma and flavor also influence its churnability so that churning occurs in a shorter time and, in the case of raw cream, is more exhaustive; the non-volatile acids are undoubtedly more important in this connection than the volatile acids since the former are present in the larger amounts.

The volatile acidity of a starter or a lot of ripened cream is very difficult to determine accurately. Hammer and Bailey have used a method consisting of distilling with steam a 250-gram sample of the fermented material, after adding 15 cc. of approximately N/1 H_2SO_4, and titrating the first liter of distillate with N/10 NaOH using phenolphthalein as an indicator; the results are expressed as the number of cubic centimeters of the alkali required. By this method only a portion of the volatile acids is secured and it is probable that the per cent of the total obtained is not always the same but the method yields results that are of significance in studying certain starter problems.

The work recently done on starters has shown that a good well-ripened starter has a more or less definite volatile acidity which amounts to from 30 to 40 when determined according to the method used by Hammer and Bailey. A high volatile acidity, such as that produced by starters, is, however, no assurance that the aroma and flavor are satisfactory. Many very poor starters yield a high volatile acidity and undoubtedly one of the reasons for their poor quality is that they have developed undesirable volatile acids in unusually large amounts. Instead

of simply lacking desirable products they contain some that are decidedly objectionable. Old sour cream generally has a high volatile acidity also, but the aroma and flavor are ordinarily not desirable. It is accordingly evident that while a high volatile acidity is desirable in a starter the volatile acids must be of the right character if the aroma and flavor are to be satisfactory.

ORGANISMS NECESSARY IN A STARTER

Hammer and Bailey, Storch, and Boekhout and Ott de Vries have independently shown that organisms other than Streptococcus lacticus (the common acid-producing organism) are present in starters. Hammer has recently divided the organisms found associated with S. lacticus in the starters studied by him into two types, Streptococcus citrovorus and Streptococcus paracitrovorus; it is entirely possible that associated organisms other than these two definitely characterized types are of importance in certain starters but in the starters studied they were apparently more common than other forms.

The associated organisms are of importance mainly in the production of volatile acids. While S. citrovorus produces very little total acid in milk (usually about 0.25 per cent calculated as lactic) it produces volatile acid from the citric acid normally present and, when grown in combination with S. lacticus, from the lactic acid developed by the latter organism. S. paracitrovorus produces some acid, including lactic, in milk (from 0.39 to 0.77 per cent calculated as lactic) and produces volatile acid from the citric acid and probably also from the lactic acid produced by it or by S. lacticus. The development of volatile acid in a starter depends largely on the activity of the associated organisms since S. lacticus produces only a comparatively small amount.

S. lacticus is nearly always found in starters in larger numbers than the associated organisms and sometimes the latter make up only a very small percentage of the total flora. Occasionally a starter will be found in which S. lacticus is present in smaller numbers than the associated organisms but this is very unusual. In general S. citrovorus lives longer in old acid milk than S. lac-

ticus so there would seem to be little if any danger of the former being lost by the over-ripening of a starter, although the activity of both organisms may be seriously interfered with.

DEVELOPMENT OF STARTER CULTURES

In the development of starter cultures, attempts have frequently been made to use S. lacticus alone. In recent trials at the Iowa Agricultural Experiment Station this organism has been carried in pasteurized milk for many generations but the aroma and flavor development were unsatisfactory and in agreement with this only a low volatile acidity was secured. S. lacticus alone produces acid rapidly enough and in sufficient amounts but the cultures always lack the delicate and pleasing aroma and flavor found in good starters. Although some S. lacticus cultures produce unpleasant odors and flavors, the cultures of this organism are often undesirable because of what they lack rather than because of any definitely objectionable qualities.

When cultures of S. lacticus are carried under creamery conditions they sometimes develop into very good starters due to their becoming contaminated with the associated organisms. One of the commercial cultures at one time contained only organisms of the S. lacticus type but starters obtained it with under practical conditions were often satisfactory because of this contamination.

Starters of a good quality can be prepared quite readily by mixing S. lacticus with one of the associated organisms and carrying the mixture in the usual way. This has been done repeatedly at the Iowa Station and some very good starters have been obtained. On the other hand some of the attempts have not yielded satisfactory cultures, due to the fact that the organisms surviving pasteurization occasionally get a good opportunity for growth during the development of the first or second transfer. The best procedure found was to first grow the bacteria in sterile milk to get a considerable amount of culture of actively growing organisms; it seemed advisable also to inoculate the associated organism at least one day before S. lacticus so that the former would have a good opportunity for growth.

S. citrovorus and S. paracitrovorus and mixtures of the two have been used in combination with S. lacticus in the development of starters, and from the results secured it has been impossible to determine which was the most satisfactory; all of them have given very good starters in some of the trials.

The volatile acidities, after varying numbers of transfers, of 10 starters, 2 made with S. lacticus alone and 8 with mixtures of S. lacticus and one of the associated organisms, are given in table

TABLE 1

Volatile acidities after a number of transfers of S. lacticus alone and mixtures of S. lacticus and associated organisms. Room temperature incubation

STARTER NUMBER	ORGANISMS CONTAINED	TRANSFER NUMBER	AGE OF MILK DISTILLED	TOTAL ACIDITY CALCULATED AS PER CENT LACTIC ACID	VOLATILE ACIDITY*
			days		
1	S. lacticus	28	5	0.96	12.4
2	S. lacticus	30	5	1.02	16.3
3	S. lacticus and S. citrovorus	29	5	1.14	40.7
4	S. lacticus and S. citrovorus	29	4	1.08	44.6
5	S. lacticus and S. paracitrovorus	29	4	1.04	35.3
6	S. lacticus and S. citrovorus	30	4	1.06	46.9
7	S. lacticus and S. citrovorus	13	5	1.14	42.1
8	S. lacticus and S. paracitrovorus	13	5	1.10	32.6
9	S. lacticus and S. citrovorus	8	5	1.13	37.8
10	S. lacticus and S. citrovorus	13	5	1.13	41.7

* As explained under methods the values given represent the cubic centimeters of N/10 NaOH required to neutralize the first 1000 cc. of distillate secured when a 250-gram portion of the milk was distilled with steam after the addition of 15 cc. of approximately N/1 H_2SO_4.

1. From the results presented it is evident that starters made with S. lacticus alone gave a much lower volatile acidity even after a considerable number of transfers than starters made with mixtures of this organism and one of the associated types; the volatile acidities of the mixtures were in general the same as the values secured with good starters. The starters made with S. lacticus alone were decidedly lacking in aroma and flavor while those made with the mixtures had aromas and flavors essentially like a good starter.

Table 2 gives the volatile acidities obtained with 2 starters (one being made with S. lacticus alone and the other with a mixture of S. lacticus and S. citrovorus) after 3, 11, and 15 transfers. The results in general agree with those given in table 1 (although the volatile acidity for the S. lacticus starter is unusually low) and show that the volatile acidity developed tends to be maintained. Table 3 gives the volatile acidities secured with

TABLE 2

Volatile acidity of a starter containing S. lacticus alone compared with that of a starter containing S. lacticus and S. citrovorus. Room temperature incubation

TRANSFER NUMBER	VOLATILE ACIDITY OF STARTER FROM CULTURE CONTAINING	
	S. lacticus alone	S. lacticus and S. citrovorus
3	4.5	36.0
11	4.1	37.0
15	3.1	36.4

TABLE 3

Volatile acidities of commercial cultures carried in sterilized and pasteurized milk through a number of transfers. Room temperature incubation

STARTER FROM MANUFACTURER C						STARTER FROM MANUFACTURER A					
Sterile milk			Pasteurized milk			Sterile milk			Pasteurized milk		
Transfer number	Total acidity calculated as per cent lactic acid	Volatile acidity	Transfer number	Total acidity calculated as per cent lactic acid	Volatile acidity	Transfer number	Total acidity calculated as per cent lactic acid	Volatile acidity	Transfer number	Total acidity calculated as per cent lactic acid	Volatile acidity
3	1.00	32.6	7	0.89	33.7	3	0.99	35.3	3	0.83	31.4
6	0.95	35.2	17	1.08	30.8	7	1.01	37.9	6	0.82	24.0
9	1.04	35.8				11	1.05	33.1	8	0.95	26.4
									18	0.93	32.1

2 commercial cultures after varying numbers of transfers in both sterilized and pasteurized milk; the results show that a high volatile acidity was obtained in both types of milk with these cultures through a considerable number of transfers.

Both S. citrovorus and S. paracitrovorus have a definite restraining action on the growth of S. lacticus. This can readily be shown by inoculating either one of the associated organisms

into sterile milk and then later inoculating S. lacticus and at the same time inoculating an equal amount of an S. lacticus culture into sterile milk of the same volume as the first lot. The milk containing only S. lacticus will ordinarily curdle much quicker than the mixture and this must be attributed to the restraining action of the associated organisms on S. lacticus. The inhibitory influence of the associated types can be still more clearly shown if acid determinations are run at various times. It seems reasonable to suppose that this restraining action plays a part in starter-making in maintaining the proper balance between the organisms so that the associated types will not be eliminated by the rapid growth of S. lacticus.

FURTHER PROOF THAT STARTERS ARE NOT PURE CULTURES OF S. LACTICUS

Although the constant presence of associated organisms in good starters and the production of satisfactory starters with the usual volatile acidities from mixtures of S. lacticus and one of the associated organisms but not from S. lacticus alone is very good proof that starters are not pure cultures, other evidence is available.

Lactic acid exists in three forms which are spoken of as *d*, *l*, and *i*, the *i* being a mixture of equal parts of *d* and *l*. S. lacticus ordinarily produces *d* acid and accordingly starters would be expected to contain only *d* lactic acid if they were pure cultures of S. lacticus. However starters have been found to contain *d* acid with some *i* acid so it is evident that organisms other than S. lacticus have been active in a starter along with the S. lacticus type.

A culture of S. lacticus shows practically the same percentage of its total acid present as volatile acid at various acidities while with a starter this percentage increases with an increase in the acidity until at the time the acidity has practically ceased to increase the percentage is much higher than it ever is with a pure culture of S. lacticus. Table 4 gives data along this line for a culture of S. lacticus and for a starter which are illustrative of

the conditions found generally. The variation in the per cent of the total acidity represented by volatile acidity at different times in the development of a starter is good evidence that it is not a pure culture and when this is taken in conjunction with the practically constant percentage for a pure culture of S. lacticus the proof is still more conclusive.

TABLE 4

Relation between volatile and total acidity in a culture of S. lacticus and in a starter. Pasteurized milk; 21°C. incubation

S. LACTICUS				STARTER			
Time elapsed since inoculation	Total acidity calculated as per cent lactic acid	Volatile acidity	Per cent of total acidity represented by volatile acidity	Time elapsed since inoculation	Total acidity calculated as per cent lactic acid	Volatile acidity	Per cent of total acidity represented by volatile acidity
hours				*hours*			
20	0.66	7.5	4.1	15	0.68	7.5	3.9
23	0.72	6.3	3.2	16	0.76	10.0	4.7
39	0.81	8.1	3.6	17	0.81	11.9	5.3
				18	0.84	15.2	6.5
				19	0.86	17.1	7.2
				20	0.88	21.5	8.8
				21	0.91	26.0	10.2
				22	0.93	28.3	11.0
				39	1.10	34.5	11.3

VARIATIONS IN THE VOLATILE ACID PRODUCTION OF STARTERS

With different starters the per cent of the total acidity represented by volatile acid at any given acid content shows considerable variation. This is presumably due to variations in the comparative growth of S. lacticus and the associated type and is one of the reasons why the aroma and flavor of good starters are not always equally satisfactory. In some cases the per cent of the total acidity represented by volatile acidity was found to be about as great at the acidities to which starters are usually ripened (0.7 to 0.9 per cent calculated as lactic acid) as at higher acidities while in other cases it was not. This situation suggests the possibility of developing starters that will have a high volatile acidity at a comparatively low total acidity since this should

result in butter with plenty of aroma and flavor and at the same time with better keeping qualities than if a high total acidity had been secured, since a high acidity probably greatly favors deterioration. The use of S. citrovorus in combination with S. lacticus cultures that have been selected on the basis of their total acid production may make this possible. Preliminary experiments have shown that starters can be prepared that do not quickly show an over-ripe condition as is the case with many starters that are otherwise excellent.

TEMPERATURE OF GROWTH OF THE ASSOCIATED TYPES

S. citrovorus does not grow at 37°C. (98.6°F.) while S. paracitrovorus does. The extreme sensitiveness of S. citrovorus, which is the more common of the associated organisms, to a temperature that ordinarily is very favorable for the growth of organisms is of a great deal of significance to the starter-maker. It indicates that temperatures not properly adjusted may be the cause of unsatisfactory results with starters because they tend to destroy the balance between the organisms which must be maintained if a good flavor and aroma are to be secured. A starter carried at a temperature too high for the growth of S. citrovorus has a flavor and aroma essentially like that of a culture of S. lacticus and also a low volatile acidity.

THE PROBLEM OF MAKING A GOOD STARTER

With definite proof that good starters must contain at least two organisms, the problem of the starter-maker becomes more clearly defined. The carrying of a starter is not a question of making conditions favorable for the growth of one organism and eliminating all others but it is a problem of maintaining a delicate balance between two organisms. The delicate balance is necessary if the aroma and flavor producing materials are to be developed in the proper amounts and the most satisfactory combination. When it is definitely realized that maintaining this balance is a big task and that many factors can influence it the problem of the starter-maker will be on a more understandable basis.

THE RELATION BETWEEN GRADE CLAIMED AND ACTUAL GRADE OF BUTTER PURCHASED IN THE RETAIL MARKET

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The prices paid for foodstuffs in the retail markets are justly assumed by the consumer to be based on either quality or food value. On certain kinds of food the differences in food value are too slight to warrant differences in price. In such cases he assumes the price to vary according to quality primarily. Butter is a good example of this group. In the larger wholesale markets butter is generally sold on the basis of grade or quality as determined by score. Such grading systems are made officially by produce exchanges and wholesale "butter boards" in the large cities which are centers of the produce trade. In distributing to the consumer, however, the retailer usually bases his price on what he pays to the jobber or wholesaler rather than upon recognized standards of quality. There thus frequently comes to be some disparity between the price paid by the consumer and the actual quality of the product as determined by score. This condition may again be complicated by the number of dealers interposed between the large produce market and the actual retailer, so that the final selling price sometimes seems to have but little relation to the grade established by the official scorer.

In a series of butter samples collected for another purpose, so great divergence was found between price paid and the score that the collection of further samples were made to include as many brands as possible. Each of these samples was scored by a competent butter scorer, and the price, score and comments of the judge were tabulated with further data resulting from the examination. The contrast of the quality claimed and price paid with the quality found seems sufficiently important to present separately.

In all, 73 samples of butter were purchased in the retail markets of 3 different cities, between June 7 and September 28, 1920. These butters were bought from retailers catering to every class of trade. Of 73 samples of butter bought 60 were claimed by the retailer to be first grade, 6 to be second grade, 2 to be "good butter," 2 to be "process" or "renovated," 1 country butter, and for 2 no grade at all was claimed. The accompanying table gives the sample numbers of the butter, dates of purchase, score, comments of scorer, grade claimed by the retailer, comments of retailer, retail price per pound, and wholesale price per pound of the particular grade or score on the wholesale butter market of New York for the day on which each sample was purchased. Of the 73 samples of butter, 6 scored 93 and above, 14 scored 91 or 92, 22 scored 89 or 90, 17 scored 87 or 88, and 14 scored 86 and below. One of the last group was found "not fit to score."

There is a marked contrast between the grade claimed by the retailer and the actual grade according to the judgment of an expert butter scorer. This contrast was so marked in some cases that very low-grade butter was sold as first-grade by the retailer. The price charged for such butters was always in keeping with the quality claimed, which means that the prices of high-grade butters were paid by the consumer for lower-grade products. In one case a butter claimed to be first grade and sold for 70 cents a pound was characterized as "not fit to score" by the butter scorer.

Not only were the grades claimed by the retailer misleading, but the prices charged did not bear any relation to the wholesale price of each commercial grade as determined by score. Butter which on the wholesale market of New York would sell at 49 cents per pound was sold retail for 70 cents per pound, whereas butter which would sell at 58½ cents per pound wholesale was sold in one market for 65 cents per pound retail. Other examples of this inconsistency are shown in the table. Butters numbered 1 to 46 show a greater divergence in this respect than butters numbered 57 to 73 from a different city, but quite the same or better condition than those from the third city numbered 47 to 56. This is to be expected in view of the fact that the retail

markets of that city are in close contact with wholesale markets and can obtain butter at short notice. In the other two markets, the butter is not so fresh, in most cases, and the quality at time of purchase may be due in part to being held for considerable periods at temperature higher than those of cold storage. However, this fact should not be held responsible for the extreme differences noted in the table, both in the grades claimed and actual grade, and in wholesale and retail prices. The price of a pound of butter in these markets reflects not the quality of the product, but its commercial history supplemented by the efforts of the dealer to assure customers that he is selling high-grade butter.

The consumer has usually no choice but to buy butter offered at the grade claimed, so that frequently very poor butter is paid for at the price of really good butter. The buyer is entitled to be correctly advised of the quality of the product offered. Many purchasers are unable to judge butter correctly in the market, hence must depend upon the recommendation of the seller. Those who are determined to have good butter can only obtain it by extensive "shopping" with great inconvenience and often added expense. Some system of retailing by grade, in which the retail price would bear a proper relation to the wholesale price of each grade, would be the fair way of selling such a commodity as butter. How best to establish such a system of butter marketing is a problem for the industry.

In the table the terminology used for indicating the commercial grades may be a little misleading to the layman. For example, "firsts" are really classified according to butter scorers as second grade, "extras" and "higher scoring" as first grade, and "seconds" as third grade, while "lower grade" is termed "below classification" by the butter scorer. Having this in mind, the differences noted are sharper than would be indicated by the terminology given.

Although the number of samples reported is not large, the condition described is clearly typical of the retail butter trade in the markets studied. The conditions in other cities are probably not

very different from those herein reported. The consumer is manifestly entitled to a more ethical and more equitable relationship between the retail selling prices of the various grades to the wholesale price of the same quality of butter. Whatever its failures and limitations in matters of detail, commercial grading safely places any given sample of butter in its proper class and such placing should be clearly evident in the price of the product at every stage of its commercial history, to insure a square deal to both producer and consumer.

SUMMARY

A comparison of quality claimed and price paid for a series of retail samples of butter showed no correlation with the actual grade and established wholesale prices of butter of the same quality.

Table showing differences between grade claimed and actual grade, and retail and wholesale prices of butter, purchased in the retail markets of three representative cities

NUMBER OF BUTTER	DATE EXAMINED, 1920	SCORE	COMMENTS OF SCORER	GRADE ACCORDING TO COMMERCIAL BUTTER GRADING	GRADE CLAIMED BY RETAILER	COMMENTS OF RETAILER (CLERK)	RETAIL PRICE PER POUND	WHOLESALE PRICE PER POUND ON NEW YORK MARKET BUREAU OF MARKETS PRICES
1	July 8	94	O.K.	Higher scoring	First	First grade	$0.65	$0.58½
2	September 18	94	O.K.	Higher scoring	First	First grade	1.20	.61
3	June 7	93	Slightly oily	Higher scoring	First	Pasteurized creamery butter, highest grade	.75	.57
4	July 30	93	O.K.	Higher scoring	First	First grade	.75	.56
5	July 30	92	O.K.	Extras	First	First grade	.70	.55½
6	August 6	92	Slight foreign flavor	Extras	First	First grade	.70	.54
7	August 6	92	Slightly coarse flavor	Extras	First	Best obtainable	.80	.54
8	September 17	92	O.K.	Extras	First	First grade creamery butter Western	.70	.59
9	July 27	91	Sour flavor	Firsts	Second	Second grade	.64	.54½
10	August 5	91	Old flavor	Firsts	First	First grade	.70	.53½
11	August 5	91	Unclean flavor	Firsts	First	First grade	.75	.53½
12	August 12	91	Slightly off	Firsts	First	First grade creamery butter	.70	.54½
13	June 7	90	Off flavor	Firsts		Good butter	.65	.53½
14	July 27	90	Sour flavor	Firsts	First	First grade	.70	.54

15	July 29	90	Old taste	Firsts	First	First grade	.75	.54
16	July 29	90	Old taste	Firsts	First	First grade	.75	.54
17	July 30	90	Overripe cream	Firsts	First	First grade	.75	.53
18	September 17	90	Sour flavor	Firsts	First	First grade	.75	.54½
19	September 17	90	Sour flavor	Firsts	First	First grade	.75	.54½
20	June 24	89	Bitter	Firsts	First	Best grade ob-obtainable	.65	.55
21	July 21	89	Oily, mealy, metallic	Firsts	First	First grade, best obtainable	.70	.54½
22	July 27	89	Slightly bitter, high moisture	Firsts	First	First grade Quality butter	.70	.53
23	July 30	89	Poor cream	Firsts	First	First grade	.73	.52
24	August 5	89	Old cream flavor	Firsts	Second	Second grade	.65	.51½
25	August 6	89	Old cream flavor	Firsts	Second	Second grade	.68	.51½
26	August 6	89	Cheesy	Firsts	First	First grade	.75	.51½
27	August 12	89	Unclean, sour	Firsts	First	First grade	.65	.52½
28	September 17	89	Unclean	Firsts	First	First grade	.75	.53
29	June 7	88	Sour	Firsts	First	Highest grade creamery butter	.70	.51
30	July 27	88	High H_2O, poor flavor	Firsts	First	First grade, excellent	.66	.52
31	July 27	88	High H_2O, poor flavor	Firsts		"Best we have"	.75	.52
32	July 27	88	Slightly bitter, high moisture	Firsts	First	First grade	.66	.52
33	August 6	88	Sour and unclean	Firsts	First	First grade	.70	.51

Table showing differences between grade claimed, etc.—Continued

NUMBER OF BUTTER	DATE EXAMINED, 1920	SCORE	COMMENTS OF SCORER	GRADE ACCORDING TO COMMERCIAL BUTTER GRADING	GRADE CLAIMED BY RETAILER	COMMENTS OF RETAILER (CLERK)	RETAIL PRICE PER POUND	WHOLESALE PRICE PER POUND ON NEW YORK MARKET BUREAU OF MARKETS PRICES
34	August 5	87	Very poor, musty	Seconds	First	First grade	.70	.50
35	August 5	87	Old and sour	Seconds	First	First grade	.70	.50
36	August 6	87	Sour and unclean	Seconds		Good grade	.60	.50
37	July 27	86	Bitter	Seconds	First	First grade	.65	.51
38	July 27	86	Bitter	Seconds	First	First grade	.64	.51
39	August 5	86	Sour or musty	Seconds	Second	Second grade	.62	.49
40	August 5	86	Musty and cheesy	Seconds	First	First grade	.55	.49
41	August 12	85	Very cheesy	State Dairy Common to fair		Creamery butter	.65	.49
42	July 29	84	Moldy	Seconds		(None claimed)	.63	.50½
43	August 5	84	Cheesy and old	Seconds	First	First grade	.60	.49
44	August 5	83	Very poor, old and cheesy	Seconds		Renovated	.60	.49
45	August 5	83	Very cheesy	Seconds		Process	.60	.49
46	August 5	0	Not fit for score	Lower grade	First	First grade	.70	.49
47	September 7	91	O.K.	Firsts	First	First grade	.70	.56½
48	September 8	89	Slightly bitter	Firsts	First	First grade	.65	.53
49	September 7	88	Flat, neutralized	Firsts	First	Excellent butter	.70	.51
50	September 7	87½	Slightly off flavor, low in salt	Seconds	First	First grade	.65	.50

51	September 7	87	High acid, cheesy curdy	Seconds			.65	.50
52	September 8	87	Flat, high salt	Seconds	First	First grade	.65	.50½
53	September 8	86	Old, stale, musty	Seconds	First	First grade	.65	.49
54	September 7	85	Flat, high salt	Seconds	First	Best butter	.65	.49
55	September 8	84	Cheesy, high salt	Seconds	First	First grade	.65	.49
56	September 7	80	Curdy, rank rancid	Lower grade	First	First grade	.65	.49
57	September 27	94	Danish butter	Higher scoring	First	Best butter we can get	.70	.63
58	September 28	93	Sweet, clean, Danish	Higher scoring	First	Finest creamery butter	.63	.62
59	September 27	92		Extras	First	Best butter	.70	.62
60	September 28	92		Extras	First	Best creamery butter	.70	.61
61	September 28	92	Sweet, clean, unsalted	Extras	First	Best butter, sweet	.76	.61
62	September 28	91	Slightly woody flavor	Firsts	First	Best butter	.76	.60
63	September 28	91	Slightly oily flavor	Firsts	First	First grade	.75	.60
64	September 27	90	Acidy	Firsts	First	First grade	.70	.58
65	September 28	90	Oily	Firsts	First	First grade	.69	.57
66	September 28	89	Lardy	Firsts	First	First grade	.67	.53½
67	September 28	89	Oily flavor	Firsts	First	Best butter	.77	.53½
68	September 28	89	Old flavor	Firsts	Second	Second grade	.67	.53½
69	September 27	88	Sour	Firsts	First	Finest butter	.70	.52½
70	September 27	88	Old, stale, curdy	Firsts	First	Best butter	.70	.52½
71	September 28	88	Slightly fishy	Firsts	First	Best obtainable	.72	.52
72	September 28	88	Foreign flavor, woody	Firsts	First	First grade	.67	.52
73	September 28	87	Strong, slight rancid	Seconds	Second	Second grade	.67	.50½

THE RELATION OF ACIDITY TO THE COAGULATION TEMPERATURE OF EVAPORATED MILK

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INTRODUCTION

In the condensed milk industry, it has always been recognized that there is a definite relation between the acidity of the milk and the temperature at which the milk coagulates in sterilization. The usual conception of the acidity of evaporated milk is that the acidity is increased in the same ratio as the solids of the milk. In other words, if fresh milk in which the titration indicated an acid content equivalent to 0.17 per cent lactic acid were concentrated in the ratio of 2.25 to 1 the resulting product would contain acid equivalent to 2.25×0.17 or 0.38 per cent. It has also been assumed that the titration of the fresh milk against a standard alkali solution would given an indication of the action of the evaporated milk under the high heat of the sterilizing process.

The development of our knowledge of the chemistry of milk in recent years has made it clear that the acid relations of the the milk are not as simple as these assumptions would indicate. It is now well established that the true acidity of a complex fluid like milk cannot be determined by titrating with alkali. This is due primarily to the fact that constituents of the milk other than the acids combine with the alkali and are titrated as acid.

Rice (1) has pointed out that the casein and the phosphates, both of which combine with alkali, are subject to sufficient variation to cause in some instances an apparent high acidity in fresh milk. A recent paper from this laboratory (2) points out that the coagulation temperature of evaporated milk is not necessarily correlated with the titratable acidity of the fresh milk.

It still remains to be determined just how much relation there is between the true acidity of the milk as measured by determin-

ing the hydrogen-ion concentration and the temperature at which the evaporated milk will curdle. Sommer and Hart (3) have shown that the time required to coagulate fresh milk from individual cows at a fixed temperature has no definite relation to its hydrogen-ion concentration. Although they show that the coagulating time is increased by changing the concentration by dilution with water, we feel that it would be unsafe to go very far in applying these results to evaporated milk. Not only is the tendency of the milk to curdle greatly increased by the concentration of the solids, but it has also been exposed to the high temperature of the forewarmer and the prolonged heating and agitation in the pan. It is well known among condensers that the forewarming has an effect on the coagulating temperature. In table 1 are given the results of some determinations on the relative coagulating temperature of fresh milk and of the same milk after evaporating to a uniform concentration of solids-not-fat of 17.7 per cent. These samples were mixed herd milks from single farms and were obtained through the courtesy of a local milk dealer. The coagulation point of the whole milk was determined by heating the milk in sealed tubes immersed in an oil bath held at a constant temperature. Since the tubes held only about 5 cc. no allowance was made for time required to bring them to the temperature of the bath.

Tubes were exposed for twenty minutes to a series of temperatures differing by 3°. The determinations on the raw milk were made just before condensing. The milk was condensed in large flasks, following as closely as possible the procedure of the condensery, including forewarming at about 95°C. The evaporated milk was usually held over night at a temperature near zero and the determination of the coagulating point made the following day.

The results on 14 samples are shown in table 1 and figure 1, in which the samples are arranged in the order of the coagulating temperature of the raw milk. It is not to be expected that the mixed herd milk would show the wide variation in the coagulating temperature found by Sommer and Hart for the milk of individual cows. It is evident from these results, first, that the variation

in the coagulating temperature of mixed milk is too small to be of value; and second, that there is no consistent relation between the narrow variation which does occur in the coagulting temperature of the mixed raw milk and that of the same milk after evaporation.

It is possible that a more accurate method of determining the coagulating point would reduce the great variation observed in some of these samples, but it is very doubtful if even this would make it safe to predict the coagulation temperature of evaporated milk from results obtained on raw milk.

TABLE 1

Relation of coagulation temperature of raw milk to coagulation temperature of milk after evaporation

LABORATORY NUMBER	RAW MILK COAGULATION TEMPERATURE, 20 MINUTE EXPOSURE		EVAPORATED MILK COAGULATION TEMPERATURE, 20 MINUTE EXPOSURE	
	°C.	°F.	°C.	°F.
673	137	278.6	128	262.4
674	134	273.2	125	257.0
685	136	276.8	112	233.6
689	137	278.6	115	239.0
684	137	278.6	131	267.8
672	140	284.0	119	246.2
670	140	284.0	113	235.4
664	140	284.0	107	224.6
663	140	284.0	105	221.0
691	141	285.8	130	266.0
688	142	287.6	133	271.4
671	143	289.4	122	251.6
669	143	289.4	125	257.0
667	146	294.8	113	235.4

In the paper quoted, Sommer and Hart emphasize the importance of the mineral constituents of the milk in maintaining the stability of the casein. Their views on this question are summarized in the following paragraph:

From the data, we see that the calcium and magnesium are balanced by the phosphates and citrates of the milk practically in gram-equivalent amounts. The sodium and potassium chlorides in the concentrations present do not have any marked influence on the coagulating point, so that the balance of the four constituents, calcium, magnesium,

citrates, and phosphates, largely determine whether a milk will coagulate or not. If calcium and magnesium are in excess, the milk will coagulate on heating. If calcium and magnesium are properly balanced with the phosphates and citrates the optimum stability obtains. If phosphates and citrates are in excess, coagulation will also result.

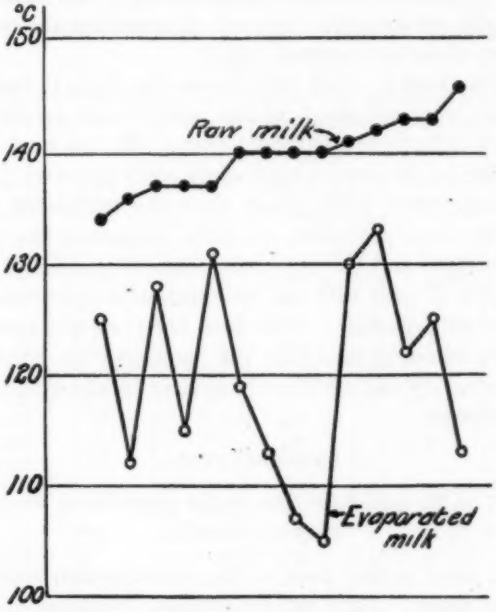

FIG. 1. COMPARISON OF THE COAGULATING TEMPERATURES OF RAW AND EVAPORATED MILK

They consider that the composition of the milk salts is the main factor in determining the coagulating point of fresh milk, and that the hydrogen-ion concentration, though only a minor factor in the coagulation of fresh milks, may become an important one in commercial milk. If we accept the conclusions reached in this paper, there still remain unanswered a number of questions of great interest to the manufacturer of evaporated milk. If we knew the relation of the acids to bases in a batch of milk, could

we predict the coagulation temperature of this milk after evaporation? Or, to put it on a still more practical basis, if it were possible to determine the acid-base ratio of the milk from individual farms as it comes to the factory, would it be possible to reject the milk which lowers the coagulating point of the finished product below the limit of safe sterilization? To what extent is the true acidity of the milk a factor in determining the coagulating temperature of the evaporated milk?

It should be kept in mind that the results given in Sommer and Hart's paper were obtained, as the authors are careful to point out, on fresh milk from individual cows. We are now concerned with the mixed milk from a number of cows and with the coagulation of evaporated milk rather than the untreated milk. In investigating these problems, we have compared the hydrogen-ion concentration and the acid-base ratio of a series of representative samples of milk with the coagulation temperature of these milks after evaporation. This has been supplemented by a series of experiments in which the hydrogen-ion concentration has been varied by the addition of acid or by the growth of acid-forming bacteria.

EXPERIMENTAL

The relation of the acid-base ratio to the coagulation temperature of evaporated milk

The milk used in this part of the investigation was obtained from a local dairy. Each sample represents mixed milk from a single farm and presumably was milked on the previous evening and the morning of the day it arrived at the dairy. Samples were brought to the laboratory before noon and, after taking samples for the chemical determinations, were held on ice until the following morning. The evaporation was done in flasks under a vacuum of 26 to 28 inches. Unless otherwise stated, the milk was brought to 95°C. in steam bath and drawn slowly into the flasks without holding. The amount of water which it was necessary to remove to bring the solids-not-fat to a concentration of 17.7 per cent was calculated from the solids-not-fat determination on the raw milk. The amount of water removed was

determined roughly on the graduated receiver of the distillation apparatus and more accurately by removing the boiling flask and weighing back on a balance accurate to 10 grams. In this way all samples were brought to a uniform concentration of solids-not-fat, although there was necessarily considerable variation in the fat content. After cooling the finished milk, it was sealed in baby-size cans and held over night in ice water.

TABLE 2

Relation of excess base and hydrogen-ion concentration to coagulation temperature. Samples arranged in order of coagulation temperature

NUMBER OF SAMPLE	EXCESS BASE OVER ACIDS	pH OF EVAPORATED MILK	COAGULATION, 30 MINUTES EXPOSURE IN STERILIZER		NUMBER OF SAMPLE	EXCESS BASE OVER ACIDS	pH OF EVAPORATED MILK	COAGULATION, 30 MINUTES EXPOSURE IN STERILIZER	
			°C.	°F.				°C.	°F.
667*	0.69	6.26	100	212.0	692	0.57	6.24	118	244.4
735	0.49		100	212.0	701	0.38		119	246.2
664*	0.77	6.16	102	215.6	673	0.51	6.34	119	246.2
718	0.13	6.24	104	219.2	696	0.43	6.29	119	246.2
663*	0.80	6.27	105	221.0	669	0.70		119	246.2
685	0.53	6.17	108	226.4	731	0.51	6.31	119	246.2
672	0.51	6.26	110	230.0	734		6.23	119	246.2
732	0.51	6.27	110	230.0	691	0.46	6.27	119	246.2
670	0.42	6.26	110	230.0	720	0.53		119	246.2
689	0.60	6.13	110	230.0	721	0.53		119	246.2
739	0.43		113	235.4	688	0.56	6.34	122	251.6
668	0.60	6.39	115	239.0	733		6.27	122	251.6
714	0.74		116	240.8	674	0.51	6.33	122	251.6
695	0.54	6.38	116	240.8	684	0.35	6.26	122	251.6
671	0.35	6.31	116	240.8	726	0.61	6.28	122	251.6

* Forewarmed ten minutes at 75°C. (167° F.).

The sterilization was done in a pilot sterilizer on the day following the evaporation. The cans were kept in motion during sterilization and fifteen minutes were allowed to bring the cans to the sterilizing temperature which was maintained for thirty minutes. The sterilizing temperature was increased by steps of 2° or 3° until the minimum temperature was found at which a curd was formed which did not disappear on shaking.

Calcium, magnesium, citric acid, and phosphates were determined in the raw milk. From this was calculated the excess of

base over acid as outlined in Sommer and Hart's paper. These results are given in table 2 and for convenience of comparison are plotted in figure 2 with the samples arranged in the order of excess of base over acids. If there is a direct relation between the acid-base ratio and the coagulation temperature of the evaporated milk, there should be higher coagulation temperature as the excess of base over acid approaches zero. In these samples the variation in the coagulation temperature is so great that no exact curve can be traced. Although there may be a

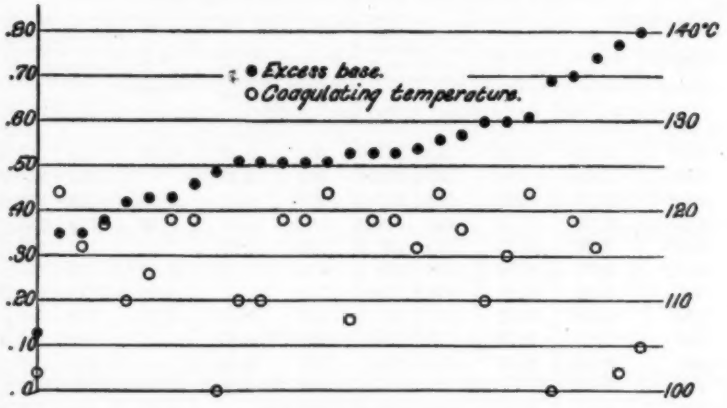

FIG. 2. THE RELATION OF EXCESS OF BASE OVER ACID IN RAW MILK TO THE COAGULATING TEMPERATURE OF EVAPORATED MILK

slight downward tendency as the excess of base increases, thereare so many exceptions that no definite conclusions can be drawn. This lack of correlation would be even more marked if samples 667, 664 and 663 were omitted. These milks were among those having a large excess of base over acid and all coagulated at 105° or lower. An examination of the records showed that these samples were forewarmed ten minutes at 75°C., rather than at 95°C., the usual procedure. Results which will be quoted later in this paper indicate that if these three samples had been heated to 95°C. the coagulating temperature would have been materially higher.

These results do not necessarily mean that the composition of the salts of milk is without influence on the temperature at which the evaporated milk curdles. It is evident, however, that whatever influence the acid-base ratio may have, it is usually obscured by other factors.

The hypothesis that the stability of the casein is, in part at least, dependent on the interrelation of the mineral constituents of the milk is supported by the effect on the coagulating temperature, of heating the milk before condensing. It seems to be a matter of general knowledge in the industry that the coagulating temperature can be raised by high or prolonged forewarming temperature.

TABLE 3

Influence of forewarming temperature on coagulation in sterilization

EXPERIMENT NUMBER	BATCH NUMBER	FOREWARMING TEMPERATURE		FOREWARMING TIME	COAGULATION TEMPERATURE	
		°C.	°F.		°C.	°F.
				minutes		
1	782	*	*		95	203.0
	783	95	203	10	125	257.0
2	786	95	203	Not held	119	246.2
	785	95	203	10	122	251.6
	784	95	203	20	125	257.0

* No forewarming.

That new equilibria are formed when milk is heated is shown by the fact that the hydrogen-ion of heated milk is always higher than that of the corresponding raw milk. Milroy (4) has shown that heating milk to high temperatures precipitates part of the calcium, and Sommer and Hart suggest that this reaction probably explains the increased stability brought about by the high forewarming. The effect of forewarming to 95°C. is usually to raise the coagulating temperature of the evaporated milk by 15° to 30°C. This is shown in table 3.

The influence of the time factor is shown in the last experiment given in this table, in which the coaglating temperature of 119°C., obtained when the milk was heated to 95°C., was raised to 122°C.

by holding at 95°C. ten minutes, and to 125°C. by holding twenty minutes. These results would indicate that while the major part of the calcium precipitation was brought about by the heating to 95°C. there was a continued small precipitation when the milk was maintained at this temperature.

Influence of the hydrogen-ion concentration on the coagulating temperature

It is very difficult to separate the effect of the hydrogen-ion concentration from that of the composition of the salts of the milk. Any change in the latter, by raising or lowering the buffer action, changes the hydrogen-ion concentration; and the low coagulating point obtained by altering the acid-base ratio may be due to the disturbance in the chemical union through which the minerals stabilize the casein, or to an increase in the hydrogen-ions.

The relation of the hydrogen-ion concentration of normal herd milk to heat coagulation after condensing was determined on the same lots of milk as were used for the acid-base investigation, and the results are also given in table 2. The hydrogen-ion determinations were made electrometrically and are expressed in terms of Sörensen's scale; these terms, it should be remembered, vary inversely as the hydrogen-ion concentration.

When milk is concentrated there is a decrease in the pH; in other words an increase in the acidity. This change is very uniform, as may be seen in table 4. The decrease in 17 samples averages very closely 0.25. This excepts sample 695, which may have been an error or may possibly have been due to rapid growth of bacteria in the raw milk before the determination could be completed. It was evident from these results that the pH of the evaporated could be used as satisfactorily as that of the raw milk for this investigation.

It will be noted that there is a very considerable variation in the pH of the different samples. In order to bring out such relation as may exist between this variation in the pH and the coagulating point, the results tabulated in table 2 are shown graphically in figure 3. In this the samples are arranged in

the order of the pH values with the scale reversed so that the dots represent a series of samples of decreasing acidity.

TABLE 4

Change in hydrogen-ion concentration in condensing

NUMBER OF SAMPLE	pH OF RAW MILK	pH OF EVAPORATED BEFORE STERILIZING	DECREASE IN pH
663	6.50	6.27	0.23
664	6.45	6.16	0.27
667	6.55	6.26	0.29
668	6.60	6.39	0.21
669	6.58	6.36	0.22
670	6.50	6.26	0.24
671	6.57	6.31	0.26
672	6.49	6.26	0.23
673	6.58	6.34	0.24
674	6.57	6.33	0.24
684	6.50	6.26	0.24
685	6.41	6.17	0.24
689	6.36	6.13	0.23
691	6.57	6.27	0.30
692	6.56	6.24	0.22
695	6.43	6.38	0.05
696	6.54	6.29	0.25
718	6.52	6.24	0.28

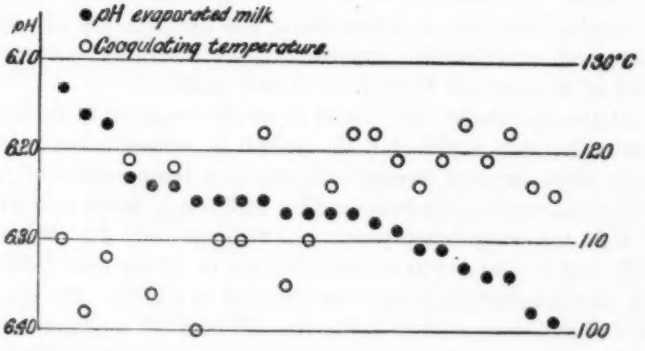

FIG. 3. THE RELATION OF HYDROGEN-ION CONCENTRATION TO THE COAGULATING TEMPERATURE OF EVAPORATED MILK

The coagulating temperature for each sample is shown by a circle directly under the dot representing the pH of that milk before sterilization. If there is a direct relation between the acidity as measured by the pH determination and the coagulation temperature, the latter should be higher as the pH curve goes down.

We find that while there is a general tendency upward in the coagulating temperatures, the variation is so great that even an approximate curve cannot be drawn. Nor is it possible to draw a line in the pH curve below which the milk may be expected to curdle at a low temperature and above which it may be sterilized without fear of curdling. It is true that all of the samples curdling below 115°C. had a pH of 6.27 or lower, but the variation is so great that no rule can be established, at least not from the data now available.

This is particularly evident in the four samples with a pH of 6.27, coagulating respectively at 105°, 110°, 119° and 122°C. Sample 663, coagulating at 105°, should be excluded on account of its low forewarming temperature. A similar variation is found in the four samples with a pH of 6.26.

It should not be inferred from this that the hydrogen-ion concentration of the milk is not a factor in the heat coagulation of the milk. On the contrary it is to be expected that it would have a decided influence in determining the temperature of coagulation, and experimental evidence shows that this is even more true of evaporated than it is of raw milk.

In an experiment, the results of which are given in table 5, the raw milk with a pH of 6.45 curdled in sealed tubes in an oil bath when exposed twenty-minutes to a temperature of 140°C. When the acidity was increased by addition of lactic acid to a pH of 6.29 the coagulation point was reduced only 3°. When this milk was condensed to a concentration of 14 per cent solids-not-fat, the coagulation point was reduced to 135°C. By the addition of sufficient acid to bring the pH to 6.16, a change of 0.20, the coagulation point was reduced 25°C. A change of 0.24 in the pH of the portion condensed to 18 per cent solids not fat reduced the coagulation point 38°C. and an equal change was produced in the 22 per cent milk by a change of 0.67 in the pH.

TABLE 5

Effect of changes in hydrogen-ion concentration in milks of varying concentration. Hydrogen-ion concentration increased by the addition of acid

CONCENTRATION SOLIDS NOT FAT	pH	COAGULATION TEMPERATURE, 20 MINUTES EXPOSURE		CHANGE IN pH	CHANGE IN COAGULATION TEMPERATURE	
		°C.	°F.		°C.	°F.
per cent						
Normal	6.45	140	284.0			
	6.29	137	278.6	0.16	3	5.4
14	6.36	135	275.0			
	6.16	110	230.0	0.20	25	45.0
18	6.30	133	271.4			
	6.06	95	203.0	0.24	38	68.4
22	6.16	125	257.0			
	6.09	87	188.6	0.07	38	68.4

TABLE 6

Effect of changes in hydrogen-ion concentration brought about by the growth of bacteria on the coagulation of the evaporated milk

NUMBER OF SAMPLE	INOCULATION	INCUBATION TIME	pH EVAPORATED	COAGULATING TEMPERATURE, 30 MINUTES EXPOSURE	
				°C.	°F.
		hours			
726	None	4	6.28	122	251.6
727	Lactic	4	6.17	106	222.8
731	None	4	6.31	119	246.2
732	Lactic	4	6.27	110	230.0
733	None	2½	6.27	122	251.6
734	Lactic	2½	6.23	119	246.2
738	None	2	6.24	113	235.4
737	Lactic	2	6.21	110	230.0
736	Lactic	3	6.18	107	224.6
745	None	2½	6.24	119	246.2
744	Lactic	2½	6.19	113	235.4
743	Lactic	2½	6.12	107	224.6

The results shown in table 6, in which the change in acidity was produced in the raw milk by the growth of acid-producing bacteria, are more comparable with factory conditions. We find that changes in the pH as small as 0.03 or 0.04 have a very appreciable effect on the coagulation temperature.

The results of an experiment designed to show the relation between the growth of bacteria, the change in acidity, and the coagulation point are shown in table 7. In this experiment 220 pounds of fresh whole milk was inoculated with 200 cc. of an active lactic culture in milk. After inoculation, the milk was warmed to 30°C. (86°F.) and held at room temperature. Bacteriological plates, using milk powder agar, were made at one-hour intervals. Immediately after inoculating, one-third of the milk was

TABLE 7

Influence of the growth of acid-forming bacteria on the coagulating temperature

AGE	BACTERIA IN RAW MILK		TITRATABLE ACIDITY	pH		COAGULATION TEMPERATURE	
	Total	Lactic		Raw	Evaporated	°C.	°F.
hours	*per cc.*	*per cc.*	*per cent*				
0	1,140,000	790,000	0.17	6.57	6.33	119	246.2
1	6,200,000	3,600,000					
2	20,950,000	13,950,000					
3	47,500,000	30,500,000	0.175	6.51	6.27	113	235.4
4½	96,000,000	53,500,000	0.207	6.43	6.21	110	230.0

forewarmed ten minutes at 95°C. (203°F.) and condensed in the laboratory pan to a concentration of 17.7 per cent solids not fat. This milk coagulated in the pilot sterilizer at 119°C. (246.2°F.).

At the end of three hours there was a distinct change in the hydrogen-ion concentration which could also be detected by careful titration with 10/N alkali.

Half of the milk remaining was condensed as before, duplicating the procedure and concentration as closely as possible. The slight change in acidity in this milk was sufficient to reduce the coagulating temperature to a point which would make the sterilization uncertain. The third portion of the milk was condensed at the end of four and a half hours, when the acidity had changed very appreciably and the coagulating point was so low that the milk could not be sterilized.

CONCLUSIONS

In the light of the results obtained in this investigation, we are unable to conclude that under commercial conditions there is any very definite relation between the acid-base ratio of the raw milk and the coagulating point of the evaporated milk. That the relation established by Sommer and Hart for fresh milk from individual cows does not hold for these conditions is probably due partly to the readjustment of this ratio brought about by a precipitation of a part of the calcium in the forewarming process and partly to the obscuring effect of other factors.

It is very evident that exact information in regard to the relations of the mineral constituents of the milk would be of little value in determining its suitability for condensing purposes.

Notwithstanding the generally accepted views as to the value of grading milk on the basis of its titratable acidity, the results obtained by determining the hydrogen-ion concentration electrometrically do not indicate that the relation between the acidity of the fresh milk and the coagulating point after it is evaporated is sufficiently uniform to make it of much value in grading milk.

This is evidently because the hydrogen-ion concentration giving the maximum stability to the casein varies with the composition of the milk. The results show that any increase from the normal hydrogen-ion concentration of milk causes a distinct reduction in the coagulation temperature after evaporation, although the final hydrogen-ion concentration may still be considerably under that of another sample which is comparatively stable. For this reason it will be difficult if not impossible to draw any definite limit in hydrogen-ion concentration above which the milk would be unsuitable for evaporating.

The essential fact which must be established in this connection is not the mere hydrogen-ion concentration of the milk, but whether this has been changed from the normal of that particular milk.

It is possible that when the milk from a large number of cows is mixed the effect of variation in composition on the hydrogen-

ion concentration would be less evident and any increase in acidity due to the growth of bacteria could be detected. Thus a titratable acidity of 0.19 or 0.20 per cent in a large batch of milk would almost certainly indicate an increase in acidity from the normal due to fermentation. The same titration in the milk from a small herd would be less conclusive; the acidity of milk from individual animals is subject to considerable variation and the value of the acidity determination becomes very questionable.

In any case it is evident that while the effect of increased acidity brought about by bacteria has a marked effect on the coagulating point, there are other factors of equal or of even greater importance which may obscure the effect of increased acidity. One of these factors is now under investigation and will be the subject of another paper.

SUMMARY

The variation in the coagulation temperature of mixed herd milk is comparatively small and has little relation to the coagulating temperature of the same milk after evaporation. Consequently the temperature at which evaporated milk made from the mixed milk of a number of cows will curdle cannot be predicted with any accuracy by determining the coagulating temperature of the raw milk.

The interrelation of the constituents of the ash of the milk, which has been shown to be a factor in determining the coagulating point of fresh milk from individual cows, is only a minor factor in determining the coagulating temperature of evaporated milk. This is partly due to the rearrangement of the acid-base relation in the condensing process, and partly to the obscuring effect of other factors, which in the mixed milk from many cows become of much greater significance.

The effect of high forewarming in raising the coagulating temperature of evaporated milk is evidently due to the precipitation of part of the calcium. Forewarming temperatures much below 95°C. (203°F.) have little effect on the coagulating temperature.

The effect of high forewarming may be increased by prolonging the heating.

There is no very definite relation between the coagulating temperature of evaporated milk and the true acidity, as measured by determining the hydrogen-ion concentration of the milk before sterilization. There is a comparatively wide limit within which the hydrogen-ion concentration may vary without influencing the coagulating temperature.

A very small increase in the acidity from the normal for that particular milk will cause a distinct lowering of the coagulating temperature of the evaporated milk.

Other factors which have not yet been fully investigated have an important influence on the coagulating temperature without appreciably changing the acidity.

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THE USE OF COTTONSEED MEAL TO INCREASE THE PERCENTAGE OF FAT IN MILK

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A high level of milk and butterfat production indicates generally economy of production, a factor of vital importance. As a consequence of this it is deemed essential at the present time that purebred dairy cattle must be backed by good records. The outcome is that large numbers of cows are tested every year for complete lactations or periods of shorter lengths and the aim in most cases is to get the highest record possible.

It has always been admitted that the amount and nature of the feed consumed by a cow would have a considerable influence on her yield of milk and butterfat though it has generally been believed that the percentage of butterfat present in the milk could not be altered to any great degree by feeding. With the rapid development of testing during the last few years every possible effort has been put forward by men to increase the fat content of the milk by feeding and as a consequence it is a by-word among dairymen that cottonseed meal, and a few other feeds will influence the fat percentage in the milk.

This factor is of greatest importance with cows on yearly test as it affects all the breeds of dairy cattle and a high fat content obtained during the two days that the tester is on the farm is used, with the total milk yield for the month, to calculate the monthly fat yield. Consequently, in outlining the work reported here, consideration was given to yearly record work rather than to testing for shorter periods. The work outlined here is only preliminary and much study is yet needed by this problem.

RÉSUMÉ OF PREVIOUS WORK

In reviewing the literature on this subject it was believed best to also review the work on other feeds of high protein content

TABLE 1

Digestible nutrients in feeds considered; after Henry and Morrison (19)

FEED	CRUDE PROTEIN	CARBOHYDRATES	FAT	TOTAL
	per cent	*per cent*	*per cent*	*per cent*
Peanut meal	42.8	20.4	7.2	79.4
Soybean meal	38.1	33.9	5.0	83.2
Cottonseed meal	37.0	21.8	8.6	78.2
Linseed oil meal (O. P.)	30.2	32.6	6.7	77.9
Gluten meal	30.2	43.9	4.4	84.0
Gluten feed	21.6	51.9	3.2	80.7
Flaxseed meal	20.6	17.0	29.0	102.8
Coconut meal	18.8	42.0	8.1	79.0
Germ oil meal	16.5	42.6	10.4	82.5

TABLE 2

Changes in fat percentage produced by peanut meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures	Backhaus (2), Juretschke (29), Kellner (34), Kochs and Ramm (32), Ramm (47), Ramm and Moller (49), Ramm, Momsen and Schumacher (50), Vieth (56)	3	2	3
Cottonseed meal	Dunlop and Bailey (11)			1
Linseed meal	Ramm, Momsen and Schumacher (50)			1
Gluten meal	Ramm (48)	1		
Coconut meal	Heirnich (18), Lund (40)			2

TABLE 3

Changes in fat percentage produced by soybean meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures	Hannson (16), Lindsey (35), Lindsey, Holland and Smith (36)		2	1
Cottonseed meal	Brooks (4)			2
Linseed meal	Hansen (17), de Vries (57)			2
Coconut meal	Lund (40)			1

which might under certain conditions give the same results as cottonseed meal. The references to work with the feeds of high protein content are extremely numerous though only a limited number bear on the problem in hand, and very few of these directly. It is quite noticeable that most of the work of this character was done at a relatively early date and few references to it are to be found in the literature of the last fifteen or twenty years.

TABLE 4

Changes in fat percentage produced by cottonseed meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Backhaus (2), Collier (6), Crowther (9), Curtiss (10), Hannson (16), Hofmann and Hansen (24), Hunt (25), Jordon (28) Lane (34), Lindsey (35), Lindsey et al (38), Lloyd (39), Michaels (41), Milburn and Richardson (42), Moore (43, 44), Porter (45), Ramm (47), Speir (52, 53)	10	10	2
Peanut meal.....	Dunlop and Bailey (11)	1		
Soybean meal.....	Brooks (4), Price (46)	2		
Linseed meal.....	Hills (23), Hunziker and Caldwell (26)	2		1
Gluten feed.....	Goessmann (14), Hunziker and Caldwell (26)	1	1	1
Coconut meal.....	Albert and Maercker (1), Buschmann (5), Ewing and Spence (12)	1		2
Germ oil meal.....	Hills (22)			1

In reviewing the earlier work only a few feeds were considered, namely the by-products of some of the oil seeds and corn by-products. Only feeds containing over 15 per cent of digestible crude protein were included, and some oil seeds not in general use in this country were omitted.

The average amounts of digestible nutrients in the feeds are given so that they may be compared conveniently, but only the

analysis for the higher grades of feed are considered and undoubtedly much of the work done with these feeds has been conducted with low grade materials. Where work has been done with cakes this is reported along with the corresponding meals.

It is impossible to discuss each investigation in detail, so for convenience the work of different workers has been tabulated acccording to the nature of the work.

TABLE 5

Changes in fat percentage produced by linseed oil meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Cranfield and Taylor (8), Farrington (18), Hannson (16), Hofmann and Hansen (24), Knieriem and Buschmann (34), Lindsey (35), Ramm, Momsen and Schumacher (50), Speir (52), Thorne, Hickman and Falkenbach (55), Wilson, Curtiss, Kent, Patrick and Eaten (58), Wall (60)	6	5	1
Peanut meal.....	Ramm, Momsen and Schumacher (50)			1
Soybean meal.....	Hansen (17), de Vries (57)	2		
Cottonseed meal.....	Hunziker and Caldwell (26)	1		1
Gluten meal.....	Goessmann (15)		1	
Gluten feed.....	Hunziker and Caldwell (26)	1		1
Flaxseed meal.....	Beglarian (3)		1	
Germ oil meal.....	Hills (22)			1

In attempting to digest the previous work on this problem two great difficulties are encountered—some feeds have received more consideration than others, and the conditions under which the various experiments have been conducted are far from uniform. However a few possible deductions are indicated.

With all feeds of high protein content that have been compared with general grain mixtures the chances are about even for an increase in fat percentage or no change; when the same feeds

TABLE 6

Changes in fat percentage produced by gluten meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Cooke (7), Hills (20, 21), Isaachsen and Solvsberg (27), Jordon (28), Ladd (33), Porter (45), Wilson, Kent, Curtiss and Patrick (59)	6	2	
Peanut meal.....	Ramm (48)			1
Linseed meal.....	Goessmann (15)		1	

TABLE 7

Changes in fat percentage produced by gluten feed

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures.....	Hills (20)	1		
Cottonseed meal.....	Goessmann (14)		1	

TABLE 8

Changes in fat percentage produced by flaxseed meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Lindsey (35), Lindsey et al (37)	2		
Linseed meal.....	Beglarian (3)		1	

TABLE 9

Changes in fat percentage produced by coconut meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Hannson (16), Juretschke (29), Knieriem and Buschmann (31), Skelton (51), Tancre (54)	4	1	
Peanut meal.....	Heinrich (18), Lund (40)	2		
Soybean meal.....	Lund (40)	1		
Cottonseed meal.....	Albert and Maercker (1), Buschmann (5), Ewing and Spence (12)	2		1

are compared with each other the chances are about even that an increase or a decrease in fat percentage will result, and on grouping all the trials together the odds are, 2 that an increased fat content will result, 1 that there will be no change, and 1 that there will be a decrease in the percentage of fat in the milk.

TABLE 10

Changes in fat percentage produced by germ oil meal

FEEDS WITH WHICH COMPARED	WRITERS	CHANGES REPORTED		
		Increase	No change	Decrease
General grain mixtures..	Hills (20, 21, 22)	2	1	
Cottonseed meal.....	Hills (22), Hunziker and Caldwell (26)	2		1
Linseed meal.....	Hills (22), Hunziker and Caldwell (26)	2		1

TABLE 11

General summary of influences of feeds of high protein content on fat percentage

FEED	GENERAL GRAIN MIXTURES; CHANGES REPORTED			OTHER HIGH PROTEIN FEEDS; CHANGES REPORTED			TOTAL CHANGES REPORTED			TOTAL NUMBER OF TRIALS
	Increase	No change	Decrease	Increase	No. change	Decrease	Increase	No. change	Decrease	
Peanut meal.....	3	2	3	1		4	4	2	7	13
Soybean meal.....		2	1			5		2	6	8
Cottonseed meal.....	10	10	2	7	1	5	17	11	7	35
Linseed meal.....	6	5	1	4	2	4	10	7	5	22
Gluten meal.....	6	2			1	1	6	3	1	10
Gluten feed.....	1				1		1	1		2
Flaxseed meal.....	2				1		2	1		3
Coconut meal.....	4	1		5		1	9	1	1	11
Germ oil meal.....	2	1		4		2	6	1	2	9
Total.....	34	23	7	21	6	22	55	29	29	113

If the individual feeds are considered it will be found that in only a few cases can such conclusions be arrived at as the number of trials is generally quite small. In the case of cottonseed meal, which entered into the largest number of trials, conditions are quite similar to those found on grouping all feeds together and the same is apparently true also for linseed oil meal, though in

the few cases where cottonseed and linseed oil meals were compared there was a tendency for the cottonseed meal to give the higher butterfat percentage.

Peanut meal does not appear to directly affect the fat content of milk as the types of change are about evenly distributed though it tended to produce a lower fat percentage when compared with the other feeds of high protein content. Coconut meal appears to increase the fat percentage of milk even when compared with cottonseed meal and other feeds of high protein content. Gluten meal shows increased fat percentage when compared with mixed grain but few comparisons have been made with other feeds containing a large amount of protein. Germ oil meal might also be said to have a tendency to increase the fat content of milk. There is not enough data available on gluten feed and flaxseed meal to allow of any statement being made regarding their value.

EXPERIMENTAL WORK

The work reported here is a record of an attempt to increase the fat content of milk temporarily by replacing certain constituents of the grain ration with cottonseed meal. In one case the cottonseed meal was substituted for oil meal and bran and in another case for corn. An effort was also made to note the result of repeating the cottonseed substitution within a short period of time.

Experiment I

In this trial 6 cows were used and the cottonseed meal was used to replace bran and oil meal in the ration. Data concerning the cows is given in table 1 and where necessary it is calculated to the first day of the experiment, November 14, 1918.

The trial was divided into check, experimental and transition periods. During the transition and check periods the basal ration was fed while the cottonseed meal was substituted during the experimental periods. The transition periods were merely the first portions of the check periods following cottonseed administration and were necessary as a means of indicating the rate of the return of production to normal. The average of the check

periods before and after any experimental period and its accompanying transition period was used as a basis with which to compare the results obtained in the experimental and transition periods.

The experimental animals were fed the roughages, corn silage and alfalfa hay, deemed necessary for their maintenance while the grain rations were uniform in composition but the amounts

TABLE 12

Animals used in experiment I

COW NUMBER	BREED	AGE	WEIGHT	FRESH	BRED
		years	*lbs.*	*days*	*days*
223	Jersey	5	890	246	96
225	Guernsey	5	950	182	14
233	Grade Holstein	4½	1000	206	85
269	Holstein	4	1160	352	142
282	Grade Holstein	3½	1110	444	132
311	Grade Holstein	3	1120	272	189

TABLE 13

Periods in experiment I

PERIOD NUMBER	NUMBER OF DAYS	WORK
I	4	Check
II	3	Experimental
III	2	Transition
IV	5	Check
V	3	Experimental
VI	3	Transition
VII	4	Check
VIII	3	Experimental
IX	2	Transition
X	4	Check

fed were determined by the production of the individual animals. The basal ration was fed throughout the check and transition periods. During period II the oil meal was replaced by cottonseed meal, while in period V the bran was taken out and cottonseed meal added and in period VIII both oil meal and bran were replaced by cottonseed meal. In each case the cottonseed meal replaced an equal weight of the other feeds and as a consequence

the highest amount of cottonseed meal fed to any cow was 6 pounds per day to cow 233 in period VIII.

The cows were milked twice daily with the exception of cow 233 which was milked three times per day. The animals were handled with the general herd and were allowed out for exercise daily. They were watered twice daily and had salt at free will.

The milk was weighed and tested for butterfat at each milking and the average daily production of milk and butterfat as well as the average percentage of fat was determined for each experimental period.

For convenience the periods are divided into three series, A, B and C, each of the series containing a check, which is the average for the check periods at the beginning and end of the series

TABLE 14

Basal ration used in experiment I

	COW NUMBER					
	223	225	233	269	282	311
	pounds	*pounds*	*pounds*	*pounds*	*pounds*	*pounds*
Corn silage	35	35	40	40	40	40
Alfalfa hay	5	5	5	5	5	5
Cracked corn	3	2	4	2	2	2
Ground oats	3	2	4	2	2	2
Wheat bran	3	2	4	2	2	2
Oil meal O. P.	1½	1	2	1	1	1

and an experimental period and transition period which are compared with the check. In each of the cases the average daily production for each animal and for the group is given.

In considering the results it is found that in series A little change in production was found on the average in the experimental period, while in the transition period there was an increase of 5 per cent in the fat content, but as this was accompanied by a 3 per cent decrease in milk yield, there was little change in the total yield of fat. In series B there was a 6 per cent increase in milk yield and a 7 per cent increase in fat yield but little change in the fat content. When series C is reached there is found to be only very small changes in the milk yield and fat content and no change at all in the fat yield.

TABLE 15

Average daily production in experiment I

PERIOD NUMBER	COW 223			COW 225			COW 233			COW 269			COW 282			COW 311			TOTAL		
	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
	lbs.	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*
I	20.8	5.59	1.17	13.4	4.85	0.65	32.4	4.00	1.30	12.4	3.66	0.45	13.5	4.23	0.57	19.8	4.94	0.98	112.2	4.55	5.11
II	21.4	4.93	1.05	14.0	4.68	0.65	34.3	4.16	1.43	13.3	3.38	0.45	14.7	4.00	0.59	18.3	5.36	0.98	115.9	4.55	5.15
III	21.2	5.78	1.23	13.1	5.33	0.70	33.4	3.80	1.27	13.4	3.61	0.48	14.9	4.20	0.62	17.9	5.72	1.02	113.7	4.68	5.32
IV	19.4	5.49	1.07	13.2	4.90	0.65	37.4	3.73	1.39	13.5	3.65	0.49	16.2	4.47	0.73	21.1	4.75	1.00	120.8	4.41	5.33
V	18.8	6.08	1.14	13.6	4.84	0.66	38.4	3.79	1.46	13.4	3.85	0.52	16.9	4.20	0.71	22.2	5.49	1.22	123.3	4.62	5.70
VI	18.6	5.55	1.03	12.4	5.42	0.67	34.6	4.22	1.46	12.3	3.85	0.47	16.0	5.04	0.81	21.5	5.31	1.14	115.2	4.84	5.58
VII	17.4	6.10	1.06	12.3	5.17	0.63	34.0	4.07	1.38	12.0	3.91	0.47	15.3	4.60	0.70	20.1	5.56	1.12	111.0	4.83	5.37
VIII	18.9	5.74	1.09	12.3	4.87	0.60	33.3	4.07	1.35	12.0	3.88	0.47	16.3	4.48	0.73	19.9	5.56	1.11	112.8	4.76	5.34
IX	18.0	6.13	1.10	12.9	4.91	0.63	35.4	3.79	1.34	12.0	3.82	0.46	16.2	4.40	0.71	21.6	5.14	1.11	115.9	4.62	5.35
X	18.4	5.93	1.09	13.6	4.84	0.66	35.6	3.83	1.36	12.3	3.87	0.48	15.4	4.30	0.66	20.5	5.43	1.11	115.8	4.63	5.36

TABLE 16

Comparison of periods in experiment I. Average daily production

SERIES	PERIOD	COW 223			COW 225			COW 233			COW 269			COW 282			COW 311			TOTAL		
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		lbs.	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*
A	Check	20.0	5.53	1.11	13.3	4.87	0.65	35.2	3.84	1.36	13.0	3.66	0.47	15.0	4.37	0.66	20.5	4.83	0.99	117.0	4.47	5.23
	Experimental	21.4	4.93	1.05	14.0	4.68	0.65	34.3	4.16	1.43	13.3	3.38	0.45	14.7	4.00	0.59	18.3	5.36	0.98	115.9	4.55	5.15
	Transition	21.2	5.78	1.23	13.1	5.33	0.70	33.4	3.80	1.27	13.4	3.61	0.48	14.9	4.20	0.62	17.9	5.72	1.02	113.7	4.68	5.32
B	Check	18.5	5.74	1.06	12.8	5.01	0.64	35.9	3.87	1.39	12.8	3.76	0.48	15.8	4.53	0.71	20.6	5.10	1.05	116.4	4.59	5.34
	Experimental	18.8	6.08	1.14	13.6	4.84	0.66	38.4	3.79	1.46	13.4	3.85	0.52	16.9	4.20	0.71	22.2	5.49	1.22	123.3	4.62	5.70
	Transition	18.6	5.55	1.03	12.4	5.42	0.67	34.6	4.22	1.46	12.3	3.85	0.47	16.0	5.04	0.81	21.5	5.31	1.14	115.2	4.84	5.58
C	Check	17.9	6.01	1.07	12.9	5.00	0.65	34.8	3.95	1.37	12.2	3.89	0.47	15.3	4.45	0.68	20.3	5.49	1.11	113.4	4.73	5.36
	Experimental	18.9	5.74	1.09	12.3	4.87	0.60	33.3	4.07	1.35	12.0	3.88	0.47	16.3	4.48	0.73	19.9	5.56	1.11	112.8	4.76	5.34
	Transition	18.0	6.13	1.10	12.9	4.91	0.63	35.4	3.79	1.34	12.0	3.82	0.46	16.2	4.40	0.71	21.6	5.14	1.11	115.9	4.62	5.35

TABLE 17

Percentage increase in production due to cottonseed meal in experiment I

SERIES	PERIOD	COW 223			COW 225			COW 233			COW 269			COW 282			COW 311			TOTAL		
		Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield
A	Experimental	7	−11	−5	5	−4	0	−3	8	5	2	−8	−4	−2	−8	−11	−11	11	−1	−1	2	−2
	Transition	6	5	10	−1	9	8	−5	−1	−7	3	−1	2	0	−4	−6	−13	18	3	−3	5	2
B	Experimental	2	6	8	6	−3	3	7	−2	5	5	2	8	7	−6	0	8	8	16	6	1	7
	Transition	1	−2	−3	−3	8	5	−4	9	5	−4	2	−2	1	11	14	4	4	9	−1	5	4
C	Experimental	6	−4	2	−5	−3	−8	−4	3	−1	−2	0	0	7	1	7	−2	1	0	−1	1	0
	Transition	1	2	3	0	−2	−3	2	−4	−2	−2	−2	−2	6	−1	5	6	−7	0	2	−2	0

Considering the changes as a whole it may be said that the substitution of cottonseed meal for other feeds of high protein content did not influence the production markedly and the effects were not immediate as the changes in the fat percentage were most marked in the transition periods following the times during which the cottonseed meal was fed. It would appear also that the continued administration of cottonseed meal at short intervals results in a decrease rather than an increase in fat content as is demonstrated in series C. Another very noticeable fact is the great variations which occur in the reactions of the individual animals towards the cottonseed meal; no two show the same changes in production.

Experiment II

For this piece of work 4 cows were used and cottonseed meal was substituted for equal weights of cracked corn. Some of the necessary data concerning the animals used is given in table 18 and where necessary it is calculated to August 6, 1919, the day on which the trial commenced.

This trial was divided into periods similar to those in experiment I but as an aid to the interpretation of the results the second period during which the cottonseed meal was fed is divided into two sections of three and four days duration respectively.

The experimental animals were on pasture and were allowed soiling ad libitum and in addition were fed a uniform basal grain ration, the corn portion of which was replaced by cottonseed meal during the experimental periods. Each cow was receiving 3 pounds of cottonseed meal daily during the experimental periods.

The cows were all milked twice daily and had salt and water at free will while on pasture. They were handled with the general milking herd and the milk was weighed and tested and the butterfat yield computed in a manner similar to that used in the first experiment.

The periods in this second experiment are divided into series D and E, similar to the groupings made in the first trial, though the experiment period in series E is considered in two portions.

The cow 319 went off feed with only 3 pounds of cottonseed meal, even when fed in conjunction with an equal weight of oil meal and an equal weight of bran. As a consequence this cow was not carried through the second section of the work and the results obtained with her are considered separately.

TABLE 18

Animals used in experiment II

COW NUMBER	BREED	AGE	WEIGHT	FRESH	BRED
		years	*pounds*	*days*	*days*
161	Holstein	9	1260	446	192
187	Guernsey	9	980	75	39
296	Grade Guernsey	4	900	187	0
319	Holstein	3½	1290	516	53

TABLE 19

Periods in experiment II

PERIOD NUMBER	NUMBER OF DAYS	WORK
I	6	Check
II	4	Experimental
III	3	Transition
IV	7	Check
V	3	Experimental i
VI	4	Experimental ii
VII	3	Transition
VIII	3	Check

TABLE 20

Basal grain ration used in experiment II

	lbs.
Cracked corn	3
Ground oats	3
Wheat bran	3
Oil meal O. P.	3

If cow 319 is left out of consideration, it is found that in series D an increase of 4 per cent in fat content and 4 per cent in fat yield with no change in the milk yield is obtained in the experimental period, while increases of 2 per cent, 12 per cent and 14 per cent are obtained in the milk yield, fat content

TABLE 21

Average daily production in experiment II

PERIOD NUMBER	COW 161			COW 187			COW 296			COW 319			TOTAL			THREE COWS		
	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
	lbs.	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*
I	18.0	3.75	0.68	27.5	3.87	1.07	22.1	4.56	1.01	19.3	4.21	0.81	86.8	4.09	3.56	67.6	4.07	2.75
II	19.2	3.90	0.75	26.3	4.25	1.12	23.6	4.63	1.09	17.7	4.12	0.73	86.7	4.25	3.69	69.0	4.29	2.96
III	18.6	4.13	0.77	26.7	4.15	1.11	24.9	5.50	1.37	8.2	6.21	0.51	78.4	4.79	3.76	70.2	4.62	3.24
IV	17.8	3.89	0.69	27.1	4.05	1.10	25.1	4.52	1.13	11.6	5.35	0.62	81.5	4.35	3.54	70.0	4.12	2.92
V	17.3	3.40	0.59	19.3	3.76	0.73	23.9	4.60	1.10							60.5	3.99	2.41
VI	18.0	3.78	0.68	24.9	3.56	0.89	23.8	4.78	1.14							66.8	4.05	2.70
VII	14.8	3.87	0.57	27.9	3.72	1.04	24.4	4.76	1.16							67.1	4.13	2.77
VIII	14.4	3.54	0.51	27.6	3.46	0.95	22.8	4.64	1.06							64.7	3.89	2.52

TABLE 22

Comparison of periods in experiment II. Average daily production

SERIES	PERIOD	COW 161			COW 187			COW 296			COW 319			TOTAL			THREE COWS		
		Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat	Milk	Fat	Fat
		lbs.	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*	*lbs.*	*per cent*	*lbs.*
D	Check	17.9	3.83	0.68	27.3	3.97	1.08	23.7	4.54	1.07	15.1	4.67	0.71	84.0	4.23	3.55	68.9	4.13	2.84
	Experimental	19.2	3.90	0.75	26.3	4.25	1.12	23.6	4.63	1.09	17.7	4.12	0.73	86.7	4.25	3.69	69.0	4.29	2.96
	Transition	18.6	4.13	1.38	26.7	4.15	1.11	24.9	5.50	1.37	8.2	6.21	0.51	78.4	4.79	3.76	70.2	4.62	3.24
E	Check	16.8	3.80	0.64	27.3	3.87	1.05	24.4	4.55	1.11							68.4	4.10	2.80
	Experimental (i)	17.3	3.40	0.59	19.3	3.76	0.73	23.9	4.60	1.10							60.5	3.99	2.41
	Experimental (ii)	18.0	3.78	0.68	24.9	3.56	0.89	23.8	4.78	1.14							66.8	4.05	2.70
	Experimental	17.7	3.62	0.64	22.5	3.63	0.82	23.9	4.70	1.12							64.1	4.03	2.58
	Transition	14.8	3.87	0.57	27.9	3.72	1.04	24.4	4.76	1.16							67.1	4.13	2.77

TABLE 23

Percentage increase in production due to cottonseed meal in experiment II

SERIES	PERIOD	COW 161			COW 187			COW 296			COW 319			TOTAL			THREE COWS		
		Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield	Milk yield	Fat per cent	Fat yield
D	Experimental	7	2	10	−4	7	4	−1	2	2	17	−12	3	3	0	4	0	4	4
	Transition	4	8	13	−2	5	3	5	21	28	−46	33	−28	−7	13	6	2	12	14
E	Experimental (i)	3	−11	−8	−29	−3	−31	−2	1	−1							−12	−3	−14
	Experimental (ii)	7	−1	6	−9	−8	−15	−2	5	3							−2	−1	−4
	Experimental	4	−5	0	−18	−6	−22	−2	3	1							−6	−2	−8
	Transition	−12	2	−11	2	−4	−1	0	5	5							−2	1	−1

and fat yield respectively. This indicates that the cottonseed meal did increase the fat content and fat yield without having much influence on the milk yield and that the full effect was not noticeable until after the administration of the cottonseed stopped. In series E there were decreases in milk yield, fat content and fat yield during the experimental period and they were most noticeable during the early part of the administration, thus showing that the second administration of cottonseed shortly after the first depressed rather than increased production of both milk and butterfat. By the time the transition period was reached and the cottonseed meal taken out of the ration, production tended to come back to normal.

In the case of cow 319 the administration of cottonseed meal for the first time depressed the fat content markedly and increased the milk yield so that there was little change in the total fat yield. The small amount of cottonseed meal used caused her to go off feed and by the time the transition period was reached the milk and fat yields had decreased enormously and the fat content showed a 33 per cent increase.

Reviewing the results of the second trial broadly it may be said that the replacing of corn with cottonseed meal tended to increase the fat content of the milk and the total yield of fat though a repetition of the work within a short time had an inhibitory effect on production. Greater uniformity was shown in the response of the cows to the cottonseed than was found in the first experiment, with the exception of one cow that was thrown off feed by a limited amount of cottonseed meal.

DISCUSSION OF RESULTS

In considering the work that has already been reported on the influence of feeds of high protein content on the fat content of milk it is found that there is no uniformity in the results obtained, and this holds true even when a feed such as cottonseed meal is considered. This lack of similarity in the results obtained is due probably to a considerable number of factors, the most important of which is undoubtedly a lack of uniformity in the

conditions under which the investigations were conducted. The basal rations differed in practically all cases and many other conditions were also allowed to vary.

When the investigations reported here are considered it is found that on substituting cottonseed meal for other feeds containing a liberal amount of protein only slight increases in the fat percentage were obtained but when cracked corn was replaced by cottonseed meal a more marked increase in fat percentage resulted. These are the two main facts but in addition it should be remembered that the increase in fat content did not take place immediately after the substitution of the cottonseed meal, that a readministration of cottonseed within a few days of the first tended to decrease rather than increase the fat content, and that cows vary in their reaction towards cottonseed, some going off feed when even limited amounts are fed.

The present day status of our knowledge does not allow of any definite reasons being given for the changes noted in the present experiments on the feeding of cottonseed meal but a few possible reasons can be discussed.

The palatability of a feed may influence not only the amount of feed consumed but also the degree to which it is utilized and so improved palatability as the result of a change in ration might lead to improved production. This cannot hold true in the cases considered however as cottonseed meal is relatively unpalatable when compared with the feeds for which it was substituted and in addition the rations were controlled in amount.

It is a recognized fact that certain feeds will bring about digestive disturbances and that sudden or radical changes in the ration will produce like effects. Cottonseed meal is one of the feeds, which, on account of its constipating action, may produce digestive troubles if introduced suddenly into the ration or if fed in considerable proportions for too long a period. This effect of the cottonseed might be supposed to have brought about the increase in fat content as digestive disturbances generally result in a decreased milk yield and increased fat percentage. However the greatest changes in fat percentage occurred where the cottonseed meal was substituted for corn and feeds that counter-

act the constipating action of the cottonseed meal, namely, oil meal and bran, were allowed to remain in the ration; and the smallest most irregular changes were produced where cottonseed meal was substituted for the laxative feeds, oil meal and bran. Consequently, therefore the changes produced cannot be attributed to digestive derangements produced by the cottonseed meal. Neither can the sudden introduction of the cottonseed meal into the ration be looked on as the cause as it was introduced suddenly into both rations. In the case of one cow only in the second experiment can the changes produced be attributed to digestive derangements produced by cottonseed meal—it was unpalatable to her, caused digestive troubles, and the limited amount fed to her put her off feed, decreased her milk production markedly and increased the fat content of the milk.

The addition of protein to a ration has been shown to increase the digestibility of protein and carbohydrate material present though this is of course most evident in the case of rations originally low in protein. The additional nutrients thus digested might be used for the production of milk and butterfat, though of course excess nutrients would be used for the production of body fat or energy. The excess of protein, over that required for maintenance and production, would be katabolised and the nitrogen excreted in the urine, though the non-nitrogeneous portions of it would be used for the production of energy. This function of the protein may explain in part the results of the two trials reported. The substitution of cottonseed meal for corn in the second trial increased the protein content of the ration markedly and so may have resulted in the increased fat content of the milk, while the replacement of other feeds by cottonseed in the other trial did not produce such a marked increase in protein content of the ration and was accompanied by no marked change in the percentage of fat in the milk.

The effect of protein in increasing the heat production of the animal body is known as its specific dynamic action and the increased katabolism brought about in this way might result directly or indirectly in an added impetus to milk production. Consequently, the increased fat percentage in the milk in the

second series might be due to this function of the additional protein provided by the cottonseed meal while the fact that the milk fat was not increased markedly in the first series may be due to the fact that the protein supply of the ration was not so markedly increased as it was in the later trial.

The protein of a feed may also have a direct stimulating action on the metabolic activities of the protoplasm of the epithelial cells in the alveoli in the mammary gland, and, if this be so, the stimulation due to the excess amount of protein supplied in the second trial might account for the increased fat percentage found in the milk at that time.

In addition to the direct influence of the protein of the cottonseed meal, other possible properties of the cottonseed meal have to be considered. It is frequently stated that the amount of fat or oil in a ration will influence the percentage of fat in milk. On the whole however, there is no definite evidence that it will do so, and the fat content of cottonseed meal differs so little from that of the feeds for which it was substituted that this factor need be given but little consideration.

It is also recognized that some feeds possess an ability to stimulate milk production quite independent of the nutrients which they contain though but little is known of these properties at present and as cottonseed was added in both trials and very dissimilar results ensued, the changes produced can hardly be attributed to any specific, but undetermined, stimulant in the cottonseed meal.

There remains another condition to consider—when cottonseed meal was administered for the second time in each experiment, there was a greater or less tendency for the fat content to decrease rather than increase. This would point to the cottonseed acting as a stimulant rather than its direct utilization for production, and to the fact that the cow, once she has reacted to its stimulating action, has to be rested for some time before she can again respond in a similar manner. Corresponding results with the use of stimulants for various purposes are quite common and need no discussion or illustration.

SUMMARY

From the work reported here the following deductions are probably justified:

1. The substitution of cottonseed meal for old-process linseed oil meal and bran in the ration of milk cows produces no marked change in the percentage of fat in milk.

2. The replacing of cracked corn with cottonseed meal under similar conditions, and in even limited amounts, tends to cause an increase in the fat content of milk.

3. All cows are not uniform in their reaction towards cottonseed meal.

4. In some cases a limited amount of cottonseed meal introduced suddenly into the ration will cause cows to lose appetite, to be subject to digestive disturbances and to decrease markedly in milk production. The large decrease in milk production will be accompanied by a high butterfat content.

5. Increases in butterfat content due to sudden administration of cottonseed meal take place in a comparatively short time and are not of long duration.

6. The readministration of cottonseed meal, before the cows have had time to recover from the effects produced during the first administration, tends to decrease rather than increase the fat content of the milk.

7. The effects produced by the cottonseed meal are probably due to some stimulating effect of the protein, either on general metabolism or on the activity of the mammary gland, which is not as yet completely understood.

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THE EFFECT OF COTTONSEED MEAL UPON THE GROWTH AND REPRODUCTION OF COWS

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Each year the problem concerning the effect of cottonseed meal upon the growth and reproduction of breeding animals becomes more acute. Cottonseed meal is one of the South's greatest feed crops and it supplies the cheapest source of protein for a large area in which the live stock industry is rapidly increasing. In the production of milk it constitutes an important part of the ration. In the feeding of beef cattle it plays an important part in the ration, and in many instances, it constitutes the sole grain ration. In the feeding and development of both classes of animals it could be used more effectively were its effects upon the growth and reproduction of such animals definitely known.

In order to secure more definite information in regard to the effect of this feed upon beef and dairy cows, the Dairy Experimental Office at Raleigh, in coöperation with the Office of Beef Cattle and Sheep, began a study in 1915. At this time the work was started on a small scale, which was preliminary work for that which is under way at the present time. In order to convey an idea of the scope of this work, it might be well to state that twenty animals were secured November 1, 1915. These animals ranged in age from six months to slightly more than a year. The average age for the entire lot being considerably under one year. The average weight of these animals at the beginning of the work was 356 pounds. These animals were divided into four lots and fed as shown in tabulation on page 335.

Before tabulating any of the results attained in this work, it may be well to again call attention to the age of these animals. The effect of a ration is more noticeable with young animals than those that are more mature. Had these rations been fed to mature cows, the results may have been far different. Therefore,

LOT NUMBER	NUMBER OF ANIMAL	RATION FED
I	327	Cotton seed meal (1 pound daily per 100 pounds live weight)
	328	Cottonseed hulls ad libitum
	329	
	330	
	331	
II	347	Cottonseed meal one-half, crushed corn one-half (1 pound daily per 100 pounds live weight)
	348	
	349	Cottonseed hulls ad libitum
	350	
	351	
III	352	Cottonseed meal (1 pound daily per 100 pounds live weight)
	353	Cottonseed hulls one-half, corn silage one-half; ad libitum
	354	
	355	
	356	
IV	357	Cottonseed meal (1 pound daily per 100 pounds live weight)
	358	Copper sulphate solution*
	359	Cottonseed hulls ad libitum
	360	
	361	
V†	362	Cottonseed meal (1 pound daily per 100 pounds live weight)
	363	Cotton seed hulls one-third; beet pulp two-thirds; ad libitum
	364	
	365	
	366	

* This solution was prepared by dissolving 1 pound of copper sulphate in 50 gallons of water and sprinkling the feed with 1 quart of this solution for each pound of cottonseed meal in the ration.

† This lot was added on December 13, 1915. The animals were older and larger than the preceding lots. The average weight of this lot being 615 pounds, Nos. 365 and 366 were several months younger than the other three.

it is unfair to assume that the results obtained in this test will, apply to all ages and classes of cows.

As the work progressed, some of the results may be noted as follows:

No. 327. Died January 21, 1916 (82 days after starting on this feed).

No. 330. Three fits followed by death on January 23, 1916 (84 days after starting on this feed).

No. 351. Fit of February 8 and another on February 26. Died March 13, 1916 (133 days after starting on this feed).

No. 349. Fit on April 30 and May 1. Died May 27, 1916. Totally blind (208 days after starting on this feed).

No. 359. Fit May 1, 1916.

No. 360. Died June 5, 1916 (217 days after starting on this feed).

No. 365. Discontinued from ration early in June. Died June 9, 1916 (221 days after starting on this feed).

No. 366. Discontinued from ration early in June. Died June 9, 1916. Totally blind (221 days after starting on this feed).

No. 328. Discontinued from ration. Died a few days later on June 10, 1916 (222 days after starting on this feed).

No. 331. Discontinued from ration. Died a few days later on June 14, 1916 (226 days after starting on this feed).

No. 329. Discontinued from ration. Died a few days later on June 14, 1916 (226 days after starting on this feed).

From the above it may be noticed that all of the animals in lot I died. The animals remaining in lots II and III were discontinued from their rations on June 11, 1916. These animals were sluggish and very much weakened.

No. 328. Aborted February 24, 1916.

No. 329. Calved April 14, 1916. Calf deformed, blind and was killed.

No. 331. Calved June 3, 1916. Calf weak. Weight 34 pounds. Died.

No. 364. Calved October 16, 1916. Calf seemed normal but died.

RESULTS AT CALVING TIME

Lots IV and V were discontinued January 1, 1917. All animals weak and partially blind, however, the three largest and oldest cows out of lot V were kept and put on a ration of cottonseed meal and hulls. The ration for these three animals (including the present time) is 1 pound of cottonseed meal daily for each 100 pound of live weight, with all the cottonseed hulls they will consume.

The numbers of these animals were changed from 362, 363 and 364 to 101, 102 and 103 respectively. At present no. 101 consumes 14.2 pounds of cottonseed meal and 24 pounds of hulls daily No. 102 receives 11.3 pounds meal with 30 pounds of hulls; and 103 gets 12.9 pounds meal and 30 pounds of hulls daily. During the summer months this meal will be reduced 50 per cent or from April 15 to October 15. The accompanying photographs will convey some idea of the condition of these animals at the present time.

OUTLINE OF THE PRESENT WORK

During March, 1919, twenty high grade calves were secured, ranging in age from two to ten weeks. These calves had been started on Blatchford's calf meal, therefore this ration was continued for six months. The aim during the first year was to keep this young herd in a good thrifty growing condition. Beginning with January, 1920, these animals were divided into five lots of four calves each. Their ration is as follows:

LOT	RATION
I	Cottonseed meal one-half, crushed oats one-half* (1 pound daily per 100 pounds live weight) Cottonseed hulls ad libitum
II	Cracked corn (1 pound daily per 100 pounds live weight) Corn silage two-thirds, corn stover one-third; ad libitum
III	Cottonseed meal one-half, cracked corn one-half (1 pound daily per 100 pounds live weight) Cottonseed hulls one-fourth, corn silage two-fourths, corn, stover one-fourth; ad libitum
IV	Cottonseed meal (1 pound daily per 100 pounds live weight) Corn silage ad libitum
V	Cracked corn three-fifths, wheat bran one-fifth, linseed meal one-fifth (1 pound daily per 100 pounds live weight) Alfalfa hay one-third, corn silage two-thirds; ad libitum

* The crushed oats will be replaced with cottonseed meal, beginning November, 1921.

These animals have been weighed each two weeks during the past year and feed adjustments made at each weighing period. The condition of the animals and the amount of growth has been fairly satisfactory up to the present, February, 1921. The growth may be noted from the following table:

LOT	AVERAGE WEIGHT BY LOTS		AVERAGE LOT GAIN
	January, 1920	February, 1921	
	pounds	*pounds*	*pounds*
I	399	824	425
II	390	722	332
III	397	826	429
IV	396	721	325
V	375	821	446

The breeding work was started about the middle of November, 1919, and at present the majority of these animals seem to be safe with calf.

FIG. 1. COW NO. 101, FEBRUARY 7, 1921

Calved February 8, 1921. Twin calves, weighed 72 and 88 pounds each; normal. Cow had been eating 14.2 pounds of cotton-seed meal daily and will be continued on this amount for four months with all the hulls she will consume.

FIG. 2. TWIN CALVES OUT OF COW NO. 101, FEBRUARY 10, 1921

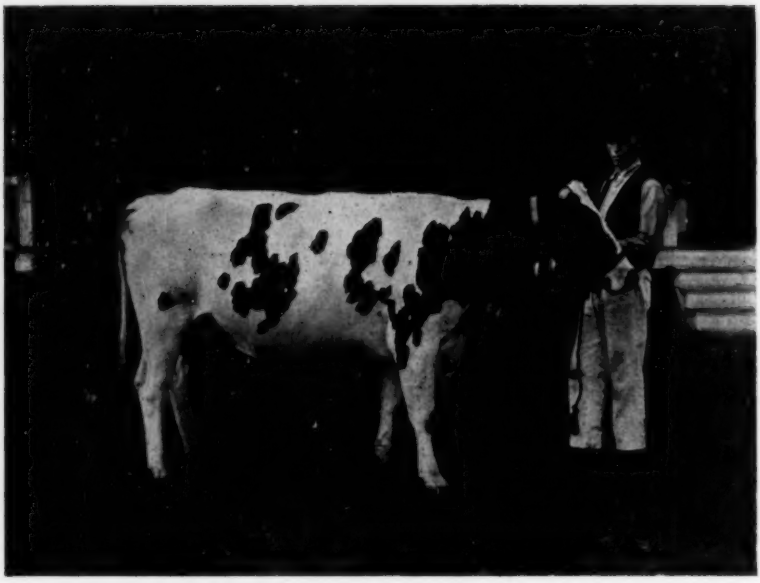

FIG. 3. COW NO. 102, JANUARY, 1920

Consuming 12.3 pounds of cotton-seed meal daily. She gave birth to twins on June 11, 1919; normal; weighed 55 and 61 pounds each. On October 6, 1920, she calved again, calf being normal and weighed 62 pounds. She is now consuming 11.3 pounds of cotton-seed meal daily, the rest of her ration being hulls.

FIG. 4. CALF OUT OF NO. 102, NOVEMBER 6, 1920

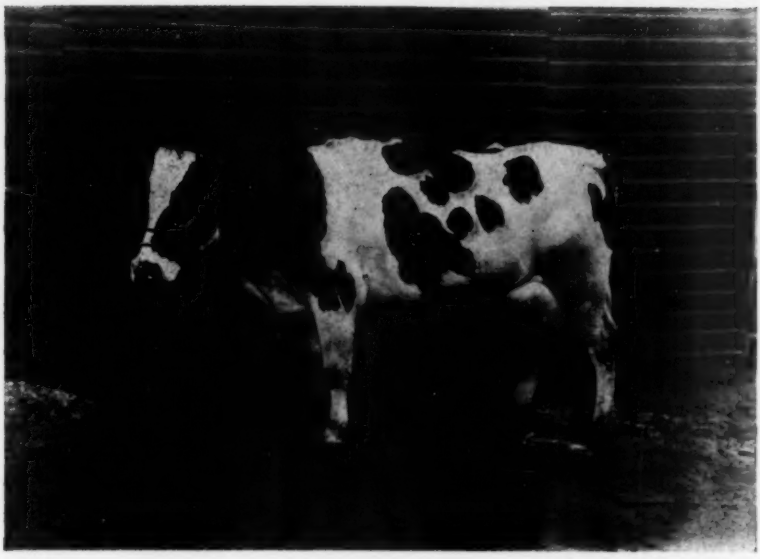

FIG. 5. COW NO. 103, NOVEMBER 30, 1920

Calved December 1, 1920. Was consuming 12.9 pounds of cotton-seed meal daily.

FIG. 6. CALF OUT OF NO. 103, JANUARY 20, 1921

AVAILABILITY AND USEFULNESS OF DAIRY STATISTICS[1]

Dairy statistics, taken in their entirety, cover a broad field. Intelligent action throughout the entire field of marketing of the industry is based largely upon current or statistical information, and the more complete and reliable the information, the more useful and valuable it becomes as a basis for safe conclusions. Undertake, for example, to study the trend of any branch of the dairy industry without reliable statistical information and you will immediately realize how futile is your attempt. Attempt to study the progress made in the pure bred cattle industry, the growth of the cow-testing or bull association movement without statistical information or attempt to determine the trend of the butter, cheese, condensed milk, or milk powder industries, without data on the monthly or annual production and it becomes obvious immediately that it is next to impossible to reach any very definite conclusions.

It would be practically useless to attempt to estimate the per capita consumption of butter or dairy products in the absence of data on production, or to attempt to make a study of the world's trade in dairy products without data regarding the exports and imports of the leading dairy countries.

In the field of advertising and merchandising, statistics are of incalculable value. If the problem be that of advertising and selling cream separators in a certain State or section, data on such factors as the following would be most useful: Number of farms, number of dairy cows, number of creameries, number of cream buying and shipping stations, amount of butter made on farms and in factories, prices of butter fat and butter compared with

[1] Report of the Committee on Statistics on Production and Marketing of Dairy Products, presented at fifth annual meeting of the American Dairy Science Association held at Chicago, Illinois, October 11, 1920. Roy C. Potts, Chairman of Committee; O. F. Hunziker, E. S. Guthrie, C. E. Lee and S. C. Thompson, members.

other sections, and the profitableness of dairying compared with other sections and with other lines of agriculture.

If the problem be that of analyzing the present condensed milk situation, the actual conditions which now exist, the causes which have produced these conditions, and the effect of possible as well as probable factors in mproving these conditions, it is statistical information that must be relied upon and used in analyzing the whole situation. Such statistics should include the monthly productions of all factories for each class of product, the stocks in the hands of manufacturers, the stocks in the hands of jobbers and wholesale grocers, the exports and imports and general market conditions, especially those affecting the demand. At the present time, the condensed milk market situation is not most satisfactory to producers or manufacturers. Later in this report, certain data available with reference to this industry will be presented and analyzed.

STATISTICS OF THE DAIRY INDUSTRY WHICH ARE VALUABLE TO THE INDUSTRY

Enough has been said in the foregoing statements to indicate clearly the value of statistics to the dairy industry. Three facts which are especially worthy of note by this Association may be mentioned:

1. A great deal of dairy statistics are at present available, but those to whom these statistics are of most value often do not know that the desired statistics exist or do not know how they may be obtained.

2. A great deal of dairy statistics which are not at present available could be made available if those in position to produce the statistics appreciated the usefulness and value of such statistics to the dairy industry.

3. Agencies of the federal government should have authority and the necessary finances to assemble from all sources the essential and useful dairy statistics and through coöperation with other agencies assist in the development of such useful statistics as are not now available.

The various dairy statistics of value to the industry may be classified as follows:

- Farm resources:
  - Acreage adapted to various crops
  - Acreage of and production of various crops
  - Comparative costs of production
- Farm equipment:
  - Dairy barns
  - Silos
  - Cream separators
- Dairy cattle (purebred vs. others):
  - Number cows in milk
  - Number heifers
  - Number bulls
- Production associations:
  - Cow testing
  - Bull associations
- Milk production:
  - Production per cow
  - Total amount produced
- Dairy factories:
  - Number, location, kind and amount of products produced.
- Uses made of milk and its products:
  - Consumed on farms
  - Manufactured on farms
  - Consumed in cities
  - Manufactured in factories
- Stocks of dairy products and substitutes:
  - Manufactured and warehouses by manufacturers
  - Received at markets
  - In hands of dealers
  - Held in cold storage
  - Shipped to foreign countries
  - Received from foreign countries
- Costs and prices:
  - Costs of dairy farming land
  - Costs of dairy cattle
  - Costs of dairy feeds
  - Costs of dairy labor

Costs of production of milk per cwt.
Costs of manufacturing dairy products
Costs of distribution of dairy products
Farm and market prices of dairy products

Referring to this classification, it will be noted that it includes two main sets of conditions: (1) Those on farms, and (2) those off of farms.

Except for the items of "Acreage adapted to various crops," which is chiefly a soil survey problem, and that of "Comparative costs of production," which is a farm management problem, the farm statistics are those which properly might be included in the agricultural census and continued annually in estimates by the Bureau of Crop Estimates[2] of the United States Department of Agriculture in coöperation with the State Department of Agriculture or State Statistical Agents of the Department.

The statistics off of farms except for those of exports and imports which are compiled by the Bureau of Foreign and Domestic Commerce of the Department of Commerce, are principally marketing statistics and the Bureau of Markets[2] of the United States Department of Agriculture is undertaking to develop these statistics with the limited funds and facilities available for such work.

ILLUSTRATIONS OF THE USES WHICH MAY BE MADE OF DAIRY STATISTICS

Illustration 1. On January 1, 1920, the Bureau of Crop Estimates reported the number of milch cows in the United States as 23,747,000 as compared with 23 455,000 January 1, 1919. What significance has this report to the dairy industry?

Potential possibilities of increased production are indicated by an increased number of dairy cows, but a study of certain other statistics must be made before we can say how this increase will affect the dairy industry. We must know in what sections the increases have occurred, also the decreases. We must

[2] On July 1, 1921, the Bureau of Crop Estimates and the Bureau of Markets were combined into one Bureau—that of "Markets and Crop Estimates."

know the conditions which caused the increase and into what market channel the increased product will be put. We should also know the trend of the uses made of milk in other sections. With such additional information, the number of dairy cows on January 1, 1920, compared with 1919, may have some definite significance to the butter and cheese manufacturer, or to the cream separator, dairy barn equipment, or silo manufacturer. This illustration is quite typical of most statistical facts. Unless other supplementary statistics are obtainable, many of the primary statistics available can not be interpreted, and without interpretation they are of limited usefulness.

Illustration 2. The total stocks of condensed and evaporated whole milk (case goods) in the hands of manufacturers on September 1, 1920 and August 1, 1920, were as follows:

	SEPTEMBER 1, 1920	AUGUST 1, 1920
Condensed case	69,691,287	65,366,996
Evaporated case	164,571,905	142,647,134

What significance have these figures to producers, manufacturers, and dealers?

We note that September 1 stocks are larger than August 1, but this alone tells us very little. We need certain other information in order to draw any very definite conclusions. First, we want to know whether the stocks on September 1, 1919, represent a normal or surplus stock. We also want to know how much of the stock reported on hand is unsold stock. We also want to know the amount of unfilled orders. Furthermore, it would be interesting to know the amount of unsold stock carried at New York City. The desirability of having this additional information will be obvious by reference to the monthly report on the "Condensed and Evaporated Milk Market," issued by the Bureau of Markets.

The following report of conditions of the market was issued by the Bureau on September 28, 1920, and is based largely on the statistical information received from manufacturers.

UNITED STATES DEPARTMENT OF AGRICULTURE BUREAU OF MARKETS,
WASHINGTON, D. C.

September 28, 1920.

CONDENSED AND EVAPORATED MILK MARKET REPORT FOR SEPTEMBER, 1920

Condensed Milk Manufacturers Close Factories in Effort to Curtail Production. Prices Decline with Decrease in Exports and Increase in Stocks.

During the past two months the condensed and evaporated milk market has steadily been getting into worse shape, and now has reached a critical stage with many manufacturers.

Export business, which stimulated increased production during the war and the building of many new factories, is now at a standstill. Companies which have been exporting have put their stocks on the domestic market, flooding it with goods which are offered at cut-rate prices in order to get their money out of it. Among the factors contributing to a decreased foreign demand is the increased production of foreign countries, which is being offered by Holland, Norway and Denmark in this and other countries at prices below our own.

It is reported that jobbers and wholesale grocers, in expectation of still lower prices, are not taking on any large stocks and are buying mostly for immediate sale to retail trade. The "tight money" condition is said to be a factor with many manufacturers and jobbers, causing them to unload at least a portion of their stocks previously made of higher priced sugar at prices below actual cost.

Report of the stocks in hands of manufacturers on September 1 shows that the load carried had increased, while unfilled orders had become practically "nil" on bulk goods and on case goods they were below those of August 1. Some firms reported their stocks were larger than ever in their history and the bottom had practically dropped out of the market. During September, it has been a serious question in the minds of many manufacturers as to what to do on October 1, with producers in most sections contending for higher prices for milk. Some few manufacturers have offered to coöperate with producers in further manufacturing and holding of stocks until sold, before determining prices to be paid the milk producers. Others announce they will close their factories until the present situation improves. Such action

will result in curtailed supply, permitting present stocks to be worked off at prices more satisfactory to holders.

Of the twenty-and-a-half million pounds of condensed milk exported in August, over ten million went to the United Kingdom, nearly three million to Cuba, and nearly 1½ million to the Straits Settlements. Of the five million pounds of evaporated, France took nearly two million, the United Kingdom 1,220,000 and Cuba nearly 375,000, and other countries less than 200,000 pounds each.

Current prices on evaporated case goods range from $5.00 to $7.00 per case, and on condensed, from $5.00 to $10.50; with advertised brands bringing the higher prices.

Skim condensed bulk is quoted at $8.75 to $9.50 per cwt., and condensed whole milk in bulk at $15 to $16 per cwt.

Illustration 3. It is reported that a firm in San Francisco has contracted for 1000 long tons of New Zealand butter to be delivered at a laid down price (duty paid) of less than 50 cents. We would like to know what the probabilities are of even larger quantities being exported to this country from New Zealand and the probable effect of such shipments on our markets.

Since shipments of New Zealand Butter to the United States are unusual, we may inquire where New Zealand formerly marketed her surplus, how much she marketed, her past production compared with her present, and the conditions in the country which formerly purchased the surplus of New Zealand which are operating to increase or decrease the present or future demand for New Zealand butter. Then, too, we may consider the conditions which are favorable, also unfavorable, to present and future sales in the United States.

Storage stocks on the English market are very light and both Denmark and Argentina are shipping considerable amounts to the United States and figure on continuing with even larger shipments. Some time ago the English Food Ministry contracted for 9000 tons of Danish butter at 245 shillings per cwt., c. i. f., for storage, and the entire surplus of Australia at 275 shillings per cwt., f. o. b. port in Australia. Even with these supplies, it is reported there will be quite a shortage in the English market. Canadian stocks in storage show a shortage on August 1, 1920, of over 16 per cent.

All conditions point to an urgent demand in England for New Zealand's surplus and the Food Ministry undoubtedly will offer many inducements in order to obtain it. Until contracts are made with the Food Ministry, there are very good possibilities of New Zealand butter reaching our markets throughout the coming winter season. The balance of trade and exchange situation, also other factors, seem to favor it. The cost of delivering New Zealand butter in the United States is about 4¼ cents per pound, duty paid. Butter now in storage in San Francisco will cost upwards of 50 cents during next December and January with storage carrying charges included. On this basis New Zealand butter would net the New Zealand exporter 46 cents or better, f. o. b., New Zealand, which is more than the English contract price for the Australian surplus. Unless the Food Ministry can square accounts on the contracts for Australian butter, and meet a price of 46 cents for New Zealand butter, the New Zealand butter is sure to come to our markets. (Since the foregoing was written, a report has been issued that the Food Ministry has contracted for the surplus from New Zealand at 46.6 cents, f. o. b., New Zealand.)

Other examples might be cited, but perhaps those given will suffice to indicate fully the value and usefulness of dairy statistics. This phase of dairy work is worthy of much larger development, and this Association should promote in every way possible the attainment of that end.

ROY C. POTTS,
Chairman of Committee.

THE SAMPLING OF MILK

H. F. JUDKINS

Massachusetts Agricultural College, Amherst, Massachusetts

The bulk of the market milk handled in our cities is bought by the quart, gallon, can or hundred weight, a certain base price being paid for milk containing a certain per cent of fat plus or minus a butter fat premium. The question of how to accurately determine the average per cent of fat in the milk of their patrons month by month and keep everybody satisfied is a problem milk dealers have been facing for some time.

Obivously the most accurate method would be to sample and test each patron's milk daily. This, however, would necessitate so much work as to make it impractical.

Some methods in use involve the taking of composite samples and testing them usually, every two weeks. Sometimes aliquot portions of each day's milk are taken using the sampling tube, and sometimes the same amount is taken out of each delivery by using a small dipper.

Some plants sample and test from one to five times a month and calculate the average test by adding up the tests and dividing by the number of tests made or by figuring out the true average test by determining the total pounds of fat bought during various test periods of the month and dividing this by the monthly weight of milk.

Hunziker (1) reports the following as average results on 4200 daily samples and 700 composite samples covering a period of fourteen days.

Method of sampling.	*Per cent fat*
Daily samples	4.900
Composite samples, aliquot portions	4.865
Composite samples, equal portions	4.870
Daily samples, every second day	4.914
Daily samples, every third day	4.905
Daily samples, every fourth day	4.903
Daily samples, every fifth day	4.893

It is understood in the last four cases that the sum of the tests involved was divided by the number of tests to get the average test for the period. This point is not perfectly clear, however.

Kent (2) compared the daily and composite tests for a period of thirteen days. There were fifty-two patrons. Three samples were taken as follows from the milk delivered by each patron. A daily test sample, a composite sample obtained by use of a small dipper, and a composite sample for which a Scoville sampling tube was used. The average test was 4.01 per cent, the dipper composite test was 3.95 per cent and the Scoville tube composite was 4 per cent.

Potts (3) carried on the following experiment taking composite and daily samples in the following manner: Composite A was taken with a little dipper which was attached to a stirring rod, B was taken with a metal tube which very nearly secured an aliquot portion, and C was taken rather carelessly with a McKay sampler. This milk was delivered by 60 patrons. There were 420 daily tests and 60 composite tests made. This experiment continued seven days with the following results: Daily test 4.39 per cent; composite A, 4.352 per cent; composite B, 4.363 per cent; composite C, 4.384 per cent.

He ran another set of tests for a period of fourteen days. The samples were all taken in the same manner, giving practically the same results. Daily test, 4.131 per cent; composite A, 4.039 per cent; composite B, 4.00 per cent, and composite C, 4.044 per cent.

All the above results indicate that any of the various methods used were accurate enough for practical purposes.

With the idea of checking up this work over a longer period of time and showing variations, the writer carried on an experiment during January and February, 1920. The milk of the 12 patrons delivering milk to the Massachusetts Agricultural College Dairy Department was sampled and tested daily. Composite samples were also taken with the milk thief and a small dipper, and tested twice a month. The Department buys its milk at a base price per quart for 3.5 per cent milk plus or minus one-tenth of a cent a quart for each tenth of a per cent of fat

above or below 3.5. per cent. Milk is paid for once a month, hence the need of getting at the monthly test of each patron's milk. In addition to the above plans, tests taken on the 15th and 30th of the month were divided by two to get the monthly average and the true average test with these two tests as the basis was also figured. This was likewise done for three tests taken on the 10th, 20th and 30th of month. These two schemes are in more or less common use in New England milk plants.

The first table shows the average tests by the various methods for the two months.

TABLE 1

Showing average percent of fat; in 12 patrons' milk for a period of two months

MONTH	POUNDS OF FAT, DAILY TEST	PER CENT OF FAT, DAILY TEST	POUNDS OF FAT, TUBE TEST	PER CENT OF FAT, TUBE TEST	POUNDS OF FAT, DIPPER TEST	PER CENT OF FAT, DIPPER TEST
January.....	1372.063	4.047	1375.912	4.058	1380.865	4.073
February.....	1498.475	3.956	1516.873	4.007	1530.907	4.044
Average.....		3.999		4.030		4.056

MONTH	POUNDS OF FAT, 2 TESTS	AVERAGE TEST, 2 TESTS	AVERAGE TEST, SUM OF 2 TESTS DIVIDED BY 2	POUNDS OF FAT, 3 TESTS	AVERAGE TEST, 3 TESTS	AVERAGE TEST, SUM OF 3 TESTS DIVIDED BY 3
January.....	1343.672	3.963	4.120	1361.926	4.011	4.025
February.....	1456.363	3.845	4.150	1493.180	3.942	4.158
Average.....		3.901	4.135		3.977	4.091

Table 1 shows a remarkably close agreement in the average test when worked out by the seven different methods. When the test is calculated by adding up two tests taken at the middle and end of the month, and dividing them by two, there seems to be the greatest difference from the average test found by daily testing. The others are in so close agreement as to be within the limit of error.

While averages may check out closely as in table 1, it becomes of interest to know how wide the variations are from the average of daily tests.

Figures in table 2 are based on the deliveries of twelve patrons covering a period of two months. The first column of figures

shows the number of times the various methods of figuring the average test for the two months differed 0.2 per cent or more from the average obtained by daily testing. The possible numbers in this column would be 24. One can see at a glance that any of the methods seem sufficiently accurate with the exception of using two tests as a basis and either calculating the true average or dividing the sum of two tests by two. Here the error is sufficiently large enough times to introduce unfairness with a number of patrons.

TABLE 2

Showing variations; in different methods of arriving at monthly average tests

METHOD	NUMBER OF TIMES DIFFERENCE IS 0.2 PER CENT OR MORE	SMALLEST DIFFERENCE	LARGEST DIFFERENCE	AVERAGE DIFFERENCE
Tube + or − daily test	1	+0.012	+0.209	+0.031
Dipper + or − daily test	1	−0.007	+0.250	+0.057
Dipper + or − tube test	0	0.000	+0.186	+0.026
Sum of 2 tests ÷ 2 + or − daily test	6	+0.009	+0.415	+0.136
True average test 2 tests + or − daily test	5	+0.007	+0.404	−0.098
True average test 3 tests + or − daily test	1	−0.015	+0.204	−0.022
Sum of 3 tests ÷ 3 + or − daily test	1	−0.003	−0.204	+0.092

The dipper and tube methods seem to be practically equally accurate methods of sampling when samples are tested every two weeks and daily deliveries of milk do not vary much in weight.

Since considerable figuring is necessary to calculate the true average test of a large number of patrons when samples are taken three times a month it is very interesting to note that the last method mentioned in the table, namely, adding up the three tests and dividing by three comes so near the results obtained by daily testing and even nearer those obtained by composite sampling. The method is worthy of recommendation. It is the method now used by the Massachusetts Agricultural College Dairy Department. Of course a possible objection to the method is, that if the sampling is done on regular days the patrons may

try to slip in some adulterated milk occasionally. However, varying the testing days so they fall at different times in the month, but at approximately ten day intervals overcomes this objection. The more times tests are taken during the month the more accurate results should be. Three times seems to be sufficient, however. About the only other alternative is to run composite samples and test them every two weeks. This involves, all told, more labor than sampling three times a month and in the summer time one is confronted with the problem of keeping composite samples in good enough condition so results will be accurate.

REFERENCES

(1) HUNZIKER, O. F.: Twenty-seventh Annual Report of the Purdue Experiment Station.
(2) KENT, F.: Testing milk and cream. Oregon Experiment Station Bul. No. 70.
(3) POTTS, A. E.: Sampling of milk. Thesis in Cornell University Library.

OPEN FORUM

Dairy Products Section Established

At the annual meeting of the Dairy Science Association held at Chicago in October, 1919, the following article was adopted as an Amendment to the Constitution of the Association.

Organization of Divisions and Sections

Article II. Professional groups based on specialized interests to be known as sections of the Society and to be formed by not less than ten active members be authorized by the executive committee when considered for the best interests of the Association.

Such sections may elect their own officers and make any rules for their own guidance not inconsistent with the constitution and by-laws of the Association.

Pursuant to this article the Dairy Products Section was established and at the annual meeting held at Chicago in October 1920, the following officers were elected. Roy C. Potts, chairman; A. W. Rudnick, secretary.

In order that a list of the members of the Section may be established, those members of the Association who desire to be considered as members[1] of the Dairy Products Section should forward their names and addresses immediately to the Secretary with the following information: (1) Present title and official position, (2) Major line of dairy work in which you are engaged, (describe fully); (3) Specific phases of dairy products work in which you are interested, (4) What in your opinion is the purpose of this section? (5) Should this Section have a definite program of work? (6) What should this program include? (7) What subject of dairy products is of foremost importance and should be first considered by this section? (8) Should the program of this section at the next annual meeting be devoted to a full and comprehensive consideration of the subject, "Practical Methods of Improving the Quality of Dairy Products?"

Roy C. Potts,
Chairman.
A. W. Rudnick,
Secretary.

[1] Prompt response from members of the Dairy Science Association who desire to be considered as members of the Dairy Products Section, is requested.—Chairman.

What is the Purpose of the Dairy Products Section of the American Dairy Science Association?

At the meeting of the Dairy Science Association, held at Chicago in October, 1920, the writer was elected chairman of the Dairy Products Section, and Professor A. W. Rudnick was elected secretary of that Section. There are at least twenty-five or more members of the Association who profess to have a deep interest in the dairy products phase of the dairy industry. Thus this section is composed of a body of men capable of giving consideration to the problems connected with the manufacture and marketing of dairy products, including every investigational, commercial and economic aspect of the subject.

The Dairy Products Section undoubtedly was established for a definite purpose and that purpose contemplated something more than a "sectional talk-fest" at each annual meeting.

Since receiving notice of my election to the chairmanship of this Section, I have given considerable thought to what that "contemplated something" should be and how it could best be attained. There are many ways in which that "contemplated something" may be expressed, but in simple terms it may be defined as, "The study of specific problems and the devising of definite aids to the manufacturing and marketing of dairy products." (If this is not correct, will others express their views and set us right?)

Assuming that the purpose has been stated correctly, we may next inquire, "What specific problems should be studied and what definite aids are most needed?" Another question immediately arises, "How should these problems be studied and how should the aids be worked out and their practical utility and value determined?"

It is quite logical to consider this latter question first, for the problems will never be solved by this Association until a plan of attack is formulated,—until a program of action is determined upon. And a definite program of action in my opinion is the greatest need of the American Dairy Science Association. The Association may have one, but if it has, it has never been brought to my attention.

In formulating a program of action for the Dairy Products Section, the writer desires the help of every member of that Section. The program devised should not be for one year only, but, if possible, for several years.

The answer to the question "How shall dairy products problems be studied?" has been indicated, and that answer definitely stated is, "Ac-

cording to a definite, well planned program of action." Among the various problems which should be studied the following are mentioned:

1. Practical grades and standards for use in buying cream for butter making purposes. (The writer questions the existence of such grades at the present time.)

2. Practical commercial market grades for milk. (At present there are many grades, most of which are impracticable for use as commercial grades.)

3. State and federal regulation of quality labels on dairy products. (Such regulation may be considered necessary to promote the marketing of dairy products on a quality basis.)

4. Increased efficiency in marketing dairy products. (Are producers' marketing organizations a step toward increased efficiency?)

5. Essential dairy marketing statistics. (What comprise such statistics and how can they best be made available to the industry?)

6. National advertising of dairy products. (Is such possible and what conditions are necessary for its success?)

The foremost problem of the dairy industry is that of improved quality in our dairy products. In an article in the next issue of the JOURNAL, this subject will be discussed and a suggested plan of solution of this problem presented. Is that plan practicable? Can the Dairy Products Section of the American Dairy Science Association suggest a practical plan or can it aid in working out a practical plan for the solution of that question? If the plan suggested in the article referred to above is not practicable, the Forum offers a medium for the exchange of ideas whereby a practical program of action for the solution of that problem by the Dairy Products Section may be discussed. Why should not the members of the Dairy Products Section use the Forum for that purpose?

ROY C. POTTS,
Chairman of Dairy Products Section.

BOOK REVIEW

The American Home Diet. Dr. E. V. McCollum and Nina Simmonds. Frederick Mathews Company, Detroit, Michigan.

In this book the authors have set forth in very clear and simple language which every reader can understand, the application to the modern American diet of the newer principles of nutrition that have been evolved during the past few years.

No greater tribute can be paid the authors than to say that it is essentially a mother's book, whose aim it is to point out specifically what constitutes a safe and wholesome diet and to simplify the mother's work in planning and providing such a diet for her family.

In order best to give the reader an appreciation of these newer principles of nutrition and their relation to health, there is a simple discussion on the relation of diet to health and the alarming increase of old age diseases and their prevention to a large extent through correct diet. Deficiencies in certain groups of foods and how these can be offset by combining with other groups not deficient in that particular food requirement, is clearly set forth. The dietary properties of the more important American foodstuffs, and their values, as well as their deficiencies, are pointed out. The value of leafy vegetables and milk and milk products as protective foods is especially emphasized. A chapter is devoted to the discussion of dangerous foods and the proper care of foods in the home. There is also a chapter devoted to the feeding of young children.

The second part of the book contains a set of menus for every day of the year. In these menus the right combination of seasonal foods and correct methods of preparation are exemplified, thus saving the housewife's time in planning the meal. A number of recipes are also included, although the authors lay no claim to having written a cook book.

In the light of the newer discoveries in the field of human nutrition this book is a corner stone upon which to build a healthier, happier and more virile American life.

J. H. F.